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PREFACE.

ACCORDING to a promise made in the preface to the first series of these lectures, and also to many private correspondents, this volume is now issued.

The Author's aim is not to preach any new doctrine but to deal with details of every-day practice, many of which are not thought of by most writers on plumbing, or are considered as being too small and trivial to be worth consideration. The successful man is the one who studies details, and it is the attention paid to small matters that either makes or mars a job in plumbers' work.

Being a good lead-bosser or a good joint-wiper is not nearly sufficient. Many such men make serious mistakes owing to their lack of knowledge of first principles. Quite recently a large college was inspected and a report made by the Author as to the sanitary conditions. Amongst the many defects discovered were about twelve wash-basins with the overflow pipes connected to the waste pipes on the wrong sides of the traps; and yet the joints and the bends in the pipes were made as well as they possibly could be.

It is not necessary to here dwell upon other such mistakes made in the execution of plumbers' work, as numbers of cases are referred to in the following pages.

These lectures are based principally on practical experiences gained during a fairly long and busy lifetime, and have been given from time to time to learners whose ages have varied from 15 to 50. There are many plumbers who have little or no opportunity to make themselves perfect in the technicalities of their trade, and it is hoped that such men will benefit by the perusal of these pages.

It may be mentioned that these lectures appeared in the *Plumber and Decorator* from 1892 to 1896.

J. WRIGHT CLARKE.

LONDON, *October*, 1903.

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LECTURES TO PLUMBERS.

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WATER-CLOSET APPARATUS.

WE have now arrived at another branch of our subject, which, if considered in all its bearings, would require more time than is at our disposal. In addition to the great variety of apparatus, we, as plumbers, have to deal with, we are hemmed in on all sides by the whims and fads, not of engineers, but "so-called" engineers and laymen of all kinds. One will advise some special kind of W.C., another man will condemn the same fitting as being objectionable. At times it becomes quite wearisome, because of the taunts of clients who, when you advise a change in an apparatus, think you do so for the sake of injuring a rival tradesman or of using some other makers goods because of a probable profit or advantage to the adviser.

With most people a W.C. is only a W.C., and nothing more. They cannot discriminate between a good and a bad kind. A nice-looking, decorated basin is everything in the eyes of some people, while others object to anything that may hide dirt or stains. Some clients appear to think that the basin is all that requires consideration; that there is some charm or hidden mystery by which the contents are emptied into the sewer or cesspool, which may perhaps be a hundred yards away. A ray of light may sometimes betray to their ignorant minds that it is really necessary to have a water-flushing arrangement attached to the basin to wash the contents away, but think that any small dribble is sufficient for the purpose. In some cases, what appears to be a fairly good flush to a W.C., is really totally inadequate. The flush may drive the paper, &c., out of the basin, but that is not sufficient. The trap, soil-pipe, and drains require to be flushed as much as the W.C. basins, but few people think of this. The thorough plumber or sanitary engineer, gives these matters the necessary consideration, but out of the large army of people who pose as experts very few know anything at all about the matter. We will now consider a few kinds of W.C.'s to illustrate the meaning of the foregoing remarks.

Fig. 450 is what is known as a common "long-hopper." This basin has been condemned by all engineers of repute for several years past, and yet thousands are found to be fixed. Judging by the numbers that can be seen in the stock of almost any maker of sanitary ware, it may safely be assumed that many more will be fixed in future years. If these basins are being fixed, somebody must be advising their use. But why are they objectionable? In the first place, because of the large internal area of

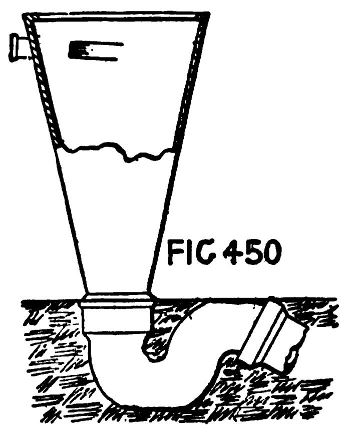

FIG 450

the basin; secondly, because of the shape, this basin is invariably found to be fouled down the back side; thirdly, because of the difficulty of flushing it clean. The flushing water enters at the side in such a way that it whirls round the basin, but does not exercise any scouring force on the sides. If the water is allowed to run for a short time, say from half to one minute, the speed at which it whirls round the basin increases to such an extent that it will frequently splash over the top onto the floor. The vortex formed by the water will act on the contents of the trap and cause them

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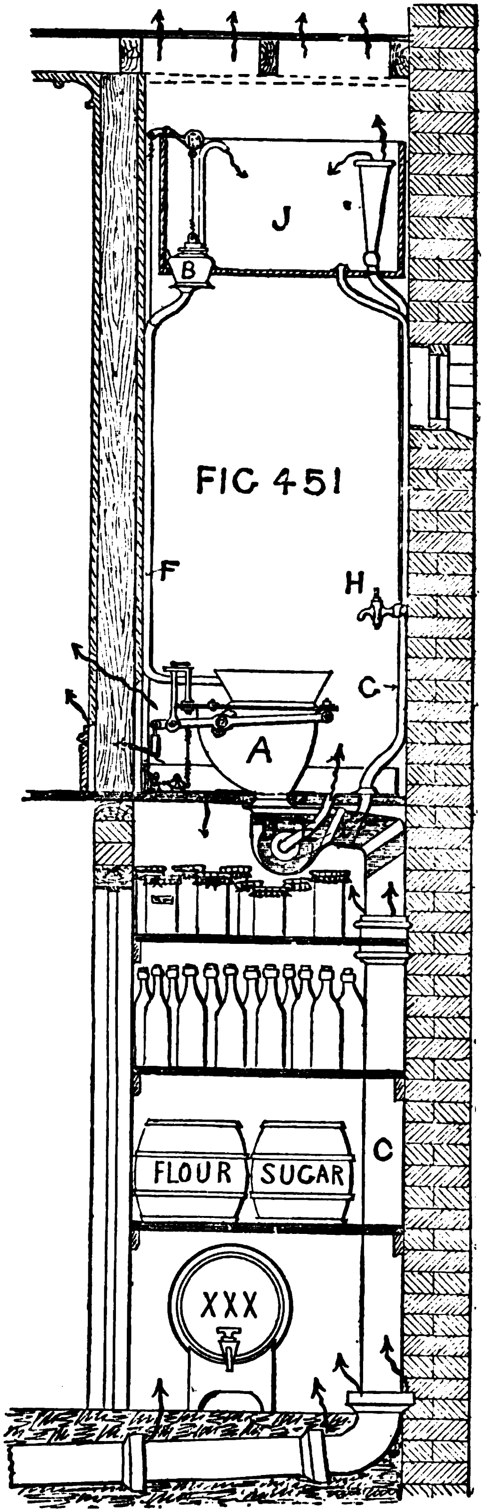
to spin round, but will entirely fail to drive them through into the drain. In some cases the writer has flushed a basin of this description, by the ordinary methods, more than a dozen times, and yet found the paper left in the trap. A pailful of water thrown down a W.C. of this kind will flush it much better than 20 or 30 gals. coming in at the side through the flushing arm.

A, Fig. 451, is another W.C. that has been condemned, lectured against, and written about in such a way that one would have thought it would never have been seen again, excepting in a museum of curios. This W.C. is still being made, sold, and fixed in large numbers, and it is dying a very hard death indeed. Some little excuse can be made for those who use them in ignorance of their unsanitary principles, but it is difficult to understand why those who have that information should persist in recommending them. As an example of this, one of my own students who attended a course of lectures and succeeded in passing his examination in a very creditable manner, afterwards started in business for himself and gave me his card, when I was horror-struck to find a closet as shown at A, Fig. 451, beautifully illustrated upon it. I find large numbers of old school plumbers who still maintain that the pan closet is the best of all kinds. Some of these old men are very difficult to deal with. Being old means that they have had a long experience. Of a kind, it is true; but those old men are very often listened to by clients in preference to the men of to-day, especially when the clients belong to the old school too. It is easy to understand why the pan W.C. is liked by some. When out of order it is easily taken up, "burnt out," as it is called, re-japanned, fitted with a new copper pan, and the brasswork re-lacquered, when it has the appearance of a new apparatus. The old plumber likes it because it gives him a job now and then, and the old client likes it because it looks likes a new one when done. Further than that, a pan closet does stand a lot of hard wear. But if the cost of keeping it in repair is considered, it will be found one of the most expensive that is used. Most of them are flushed by means of "service-boxes and valves" fixed in cisterns and worked by means of cranks and wires. This method of flushing is now found principally in country mansions, and has an advantage where the houses are not heated by hot water or other apparatus, in that the service-pipe to the W.C. is always empty, so that frost bursts are almost unknown in that pipe. But there are very few of these W.C.'s that do not require the plumber to either repair broken wires, or shorten those that have stretched to such an extent that they will not open the valves in the cistern, several times during the year. I frequently find that the "house carpenter" looks to these wires, and thus keeps them in order, so that really a gentleman does not always know what it costs him for repairs to the W.C.'s. Where pan



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closets are fixed, one rarely finds a properly constructed slop-sink, but the abominable dirty state of the container, and floor beneath, shows where the bedroom slops are emptied. In these cases, the undersides of the seats are almost invariably found to be saturated with filth.

Why is the pan closet condemned as being unsanitary? If any one cares to take the trouble to measure the inside of the large iron chamber, known as the container, the inside and outside of the copper pan, and the surfaces of the basin that are immersed in the pan, he will find that in all there is about 5 ft. superficial of fouled surfaces, and these are not simply dirty but are thickly coated with fur. This fur will sometimes accumulate to such an extent that when the W.C. handle is dropped and the copper pan is raised to its ordinary position, it will lift the basin off its seating on the container. It is not at all uncommon to find the copper pan so heavily coated that extra heavy weights have to be added to the lever, which acts on the "tumbler," to keep the pan from dropping down and raising the W.C. handle. This fur matter is mostly composed of the salts of urine which crystallise on the surfaces of the W.C. fittings with which it comes into contact. The stench from this matter is very objectionable, and can always be noticed when the W.C. handle is raised. The falling water from the basin displaces the air, which is charged with the gases from the fouled surfaces in addition to those which escape from the contents of the trap, usually a D trap, when stirred up, from inside the container into the apartment, and it needs no explanation to prove that this air is totally unfit for respiration. There is scarcely a reader of these lines who has not, at some time or other, noticed these smells, and can bear testimony to the abominable stench that an old pan apparatus gives off. Experienced plumbers have been heard to say that they could go blindfolded into a closet and tell, by the smells alone, if an apparatus of this description was fixed in it.

From time to time a great deal of ingenuity has been expended in efforts to improve the pan W.C., but it has all been wasted. One maker substituted earthenware for the iron container, as being more cleanly. A sparge pipe has been fixed inside, so that the container was flushed at the same time as the basin. The whole apparatus has been made of earthenware and so fitted up that an ordinary servant could take it to pieces, scald, clean and refix it. A ventilation pipe has been fitted for the air, inside the container, to be driven out of doors when the handle was raised. Two ventilation pipes have been fixed so that a current of air could circulate through the container. In these cases the old adage of "prevention is better than cure" has been entirely lost sight of. No effort whatever was made to prevent the fouling of the apparatus. The only object of each person has been to reduce the effects of the evils and not the evils themselves. And these remarks apply to a great many other details in the construction of sanitary fittings.

Cases have been found where a ventilation pipe has been fixed from the top of the container to the soil pipe ventilator. Such a pipe would act as a bye-pass and let drain air escape into the container, where it could pass through an ill-fitting joint round the tumbler axle, or through the basin when the W.C. handle was raised. Wherever a pan apparatus is fixed a great many other defects are generally found. Fig. 451 is an example, showing a few of the commonest. The closet is frequently fitted in a position with rooms at the side and above. The partitions are often found to be defective beneath the W.C. enclosure, so that smells can pass through. The ceiling is generally found to be defective, especially over the cistern. Arrows in the sketch show how smells can pass into a room at the side, and also into one above. The careful housewife finds a nice cool closet, on the floor below, in which to keep her stores, never for a moment thinking that a defect in the fitting above, or one in the soil pipe, which passes through the store closet, or one in the drain beneath the pavement, could do any harm. For ventilating the water-closet a small window, about 9 in. or 10 in. square, is sometimes found placed in such a position that the place is always in a state of semi-darkness, even when the sun is shining brightly outside. The lower portion of the lead soil pipe sometimes gets so bruised and battered that it has to be renewed. As iron will resist being bruised better than lead, a length of iron pipe is fixed, as shown at C in the figure. The joint between the lead and the iron is always a difficult task to make secure, and darts show an effect which is not at all uncommon. Whenever a pan apparatus is found it is usual to suspect that the D trap, D, is beneath it. Whenever a leaden safe is fixed under the W.C. the waste, E, from it will be found to be connected to the D trap. Puffs of air are driven out of this pipe whenever the W.C. handle is raised, and sometimes a portion of the contents of the trap rushes up the pipe and lays in the safe. In very old places the end of the safe waste pipe is found to be entirely furred up inside the trap. In these cases the safe is no protection, if an overflow from the W.C. takes place, to anything which may be beneath.

The apparatus is flushed by means of a valve and service box, B, in the figure, fixed in a cistern, J, immediately over it. This cistern has the front removed so as to show the inside. The pipe, F, from the cistern to the W.C. is always empty, when not in use, so that smells can pass into the cistern and through the defective flooring above. The waste pipe, G, from the cistern is generally found to be connected to the trap, and each time the W.C. handle is raised a puff of bad air is expelled from the open end of the standing pipe into the cistern. In after years the end of the pipe becomes furred up in the trap, and cisterns innumerable

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have been known to overflow and do damage because of this. The reader can readily understand that the water in the cistern, exposed as it is to contamination from the air in the closet, in addition to what escapes from the apparatus and waste pipe, is not what would be selected for drinking purposes. But it is usual to find a small tap, as shown in the figure at H, fixed in the closet for filling toilet bottles. As an apprentice, and in his younger journeyman days, the writer has fixed, and helped to fix, large numbers of W.C.'s as illustrated by Fig. 451. At that time high class architects used to specify "pan" W.C.'s and "D" traps in most of their work. Light and ventilation were never, or rarely, considered, and neither was any importance attached to the evils of W.C. smells passing into other rooms, or into drinking water cisterns. Nowadays, it is usual to condemn plumbers for all work done in an unsanitary manner, but the public ought to be reminded that there are others who are equally to blame. Years ago, all sections of people who had anything to do with sanitary work exercised themselves to the best advantage with the knowledge and materials at their command, and we ought not to be too severe in our condemnation of them. We can give them credit for what they did, and remember that the experience we have has been partially bought and paid for by our predecessors. Those who follow us will profit and gain advantage from our experiences, and probably they may look back upon us as being as ignorant as we now think our forefathers were. A great many years will pass before this takes place, and first of all we must get rid of believers in the "long hopper" and "pan" closet.

If the reader refers to Fig. 267, in an earlier lecture, he will see an old-fashioned W.C. basin with a trapped arrangement at the bottom. It is scarcely necessary to say that a basin of this shape, the absence of any flushing rim, the unsuitability of the trap, added to the difficulty of making the connection to the drain, renders the whole fitting unsatisfactory.

Another unsatisfactory kind of W.C. basin known as the "Wash-out," is shown by Fig. 452. In my book—"Plumbing Practice," I say: "This kind of water-closet is manufactured almost without exception, by every English maker of W.C.'s, and at the present time is the most popular closet of the day, being sold and fixed in thousands. This is rather strange; as amongst the hundreds that the writer has seen in use, scarcely any were found to be clean in their action, or could be kept so without the daily use of a brush. The water in the hollow is not deep enough for the fæces to be immersed in, and the stains left after being used are, in some cases, as bad as if the basin had been quite dry before using." This, although written five years ago, is the writer's opinion to this day. The first he ever saw was fixed in a house in the City of London, a great many years ago, and had the name of a Scotch firm upon it. He afterwards found what was generally known as the "Monkey-closet," being fixed in a great many places. This fell away to a considerable extent; and it has been stated that the inventor himself condemned their use some time before he died. An improved kind of basin known as the "Water Battery," was afterwards made, and the inventor of that said that he much preferred another kind,

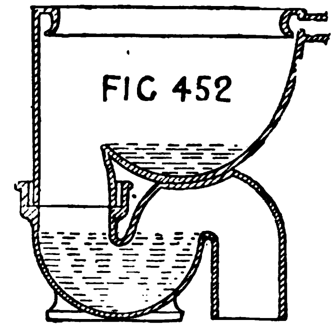
FIG 452

owing to the trouble of thoroughly flushing the contents through the trap. Patents innumerable have since then been taken out for what is really the same kind of basin, so far as its action goes, although the shape has been varied, fancy names given to it, and the exteriors highly decorated. This fitting is a proof that whenever the public "catch on" to anything, they insist upon having it in spite of any drawbacks it may have. Another disadvantage is the disgusting appearance it presents when a careless person has omitted to flush the basin after using. When used by women, the hollow of the basin is

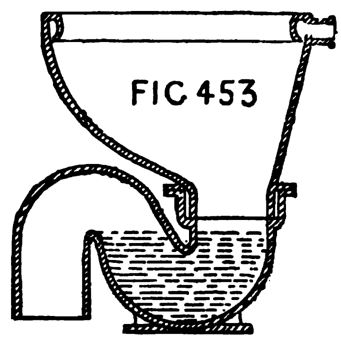
FIG 453

nearly always stained, and in some cases, quite as offensive as men's urinals.

Fig. 453, when looked at as a W.C. only, is much superior to the last one described.

Fig. 454, is of the same kind, but this one is arranged to stand without an enclosure, the basin and trap being made in one piece, of white- or stone-ware, or fireclay, the latter material being found to resist fracture from frost better than the others. The principal drawback to this basin is the small area of the surface of the water in the trap. A great many

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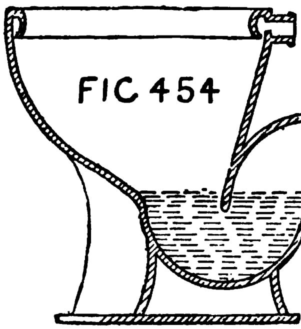
makers have succeeded in increasing this in size, and at the same time forcing all deposit through the trap by means of an ordinary water flush. This type of W.C. is made by some manufacturers with a lead trap, instead of ware. The advantages of this will be explained when we deal with the joints of this kind of W.C. to soil-pipes and drains.

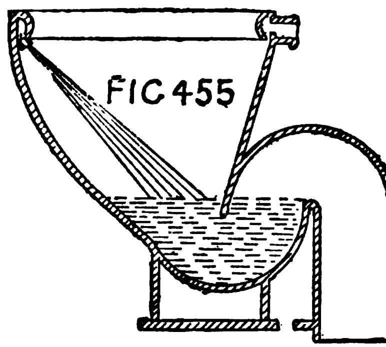
Another large firm of sanitary engineers have patented a W.C. of the foregoing description, which is fixed to the back wall, and a space left between the trap and the floor, so that the latter can be washed and cleansed. From a sanitary point of view, this, so far as the type of W.C. is concerned, may be considered as being nearly



perfection. The basins that have been described and shown by Figs. 453 and 454, are known as the "Washdown" kind, and have flushing rims to them. That is, hollow rims with perforations on the under sides are fixed round the top edges of the basins. Water streams down from the rim all round the inside of the basin, and the streams meeting in the centre, literally push all floating matters through the trap. It has been found to be an advantage to increase the area of the exposed water surface in the trap and to supplement the cleansing power of the flushing rim by means of a jet of water being made to play onto floating matters. Fig. 455, is a sketch showing this kind of W.C. in section. The successful working of this fitting depends upon a liberal water flush and the position of the jet.

Figs. 452-3-4 and 5 are sometimes called "pedestal" closets, and before dealing with another kind we will dwell upon a few points that are common to all of them. In the first place, all the traps are above the floor line, so that they are exposed to atmospheric influences. This is, in some cases, a serious evil. In cold situations the water will become frozen, thus rendering the W.C. useless for the time being. Hundreds of traps are broken every winter by the frost, so that on the water thawing it will leak out of the trap and drain air escape out of the fracture. This is a common experience of the writer's, and doubtless is also that of a great many readers. The remedy for this is to protect the fitting from frost and, if possible, use some material for the basins and traps that will resist being broken by that influence. Where W.C.'s are fixed in a wing of house that is not often used, or in houses occupied only a portion of the year, the traps being above the floor line, as above mentioned, they have been found quite empty, excepting for cobwebs, owing to the evaporation of the water. These experiences show that, under given conditions, any of the above W.C.'s are very unsuitable.

In the second place, when any of the W.C.'s under consideration are fixed upstairs, or so far above the drain that a soil pipe has to be used to connect the basin to the drain, there is some difficulty in making the joint between the trap and soil pipe. This joint has exercised the minds of plumbers and sanitary engineers for several years past, and it is an open question if the problem is yet solved how to make one that is reliable. To approach the question methodically, we ought first to ask ourselves, "What is it we want to do?" On the face it seems simple enough to make such a joint, but one that shall be lasting is the difficulty. This difficulty chiefly arises when two different kinds of materials have to be joined. Earthenware to earthenware, iron to iron, and lead to lead are easy enough. But with earthenware to lead, or



earthenware to iron it is not so easy. It may be accepted as an axiom that to make a secure joint the materials to be joined and the material used for making the joint should, as far as possible, approach each other in their physical properties. The common way for jointing the outgo of an earthenware trap to a leaden soil pipe is to loosely socket the outlet end of the former into the end of the latter, and then fill the annular space with red lead cement. Dealing with expansion and contraction first. The three materials named above do not expand and contract equally. The leaden pipe will expand the most, and in so doing will leave a space between the inside of the lead socket and the cement. It may be urged that the above named forces have nothing to do with the matter, but they have a great deal to do with it. W.C.'s are often used as slop shoots, and these slops are often heated, or mixed with hot or warm water, and it is a well known fact that even one degree variation of temperature has

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an influence on all solid substances. If we assume that no warm water is ever thrown down a W.C. we still have atmospheric changes to deal with. In an earlier lecture it was pointed out that all metals when exposed to such influences may be said to be in constant motion, and are never still even for a few seconds at a time. The motion may be too small at times to be measured, but there is the motion all the same. This would be of little or no importance if the materials used for jointing were flexible and would allow for a small amount of movement in the pipes without breaking. But the cement generally used, which is a compound of red lead, white lead, and linseed or other vegetable oil, after a time becomes very hard and brittle, so that the least movement will cause it to crack. When the cement is made of materials which are much adulterated, and this is nearly always so, it will sometimes crumble to a powder after it has been used for a few years, and the joint is then far from being a good one. If we were to assume that this kind of joint is a good one when well made, we rarely find them so. To properly make them, the parts to be joined must be properly pre-

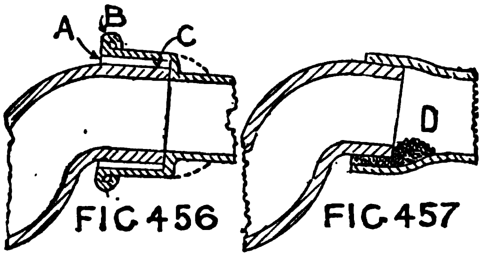

FIG 456 FIG 457

pared. The outlet of the trap should be painted a few days beforehand, otherwise the cement will not "key" to the glazed surface. The inside of the end of the lead pipe should also be painted for the same reason. This end should also be opened properly, and a socket made as shown by Fig. 456. The annular space, A, should be equal all round, and not less than ¼ in. wide. Generally speaking, we find the fitting of the pipe to the trap so carelessly done that one side has an opening of considerable size, and the other side is so close to the earthenware that it is impossible to get any cement in. The outer edge of the lead socket should have a bead worked on it at B to strengthen it, and thus make it better able to resist being distorted if a tool is used for caulking. The bottom of the lead socket should be made to fit the end of the trap, as shown at C in the figure, to prevent the cement squeezing through, and the bore of the pipe and trap should be equal and continuous. Fig. 457 is drawn to give some idea of the ordinary and slovenly way of making this joint, and at D a space in which W.C. matters can lodge, if it has not already been filled up with cement. A further difficulty presents itself when making this joint if the outgo of the trap is not perfectly round. When this is not the case the socket should be bossed to fit. An equal thickness of cement could then be left all round, and thus avoid any injury to the soundness of the joint by unequal expansion or shrinkage of the cementing material.

Another and slovenly way of making this joint is to daub some cement outside, cover it with a piece of coarse canvas, and tie it up with string, the whole presenting the appearance of a large poultice when finished. In addition to the evils prestated, there is not only the vibration of the floor on which the basin stands, caused by any users, but the movement of the basin itself, by the percussion of the water on entering or by the pressure of the seat when in contact with the basin. Some of the pedestal W.C.'s have to support from one to two cwt. at times, and if the floor on which they stand is not very firm, a great strain is brought to bear on the joints on the outlets of the traps. Hence the advisability of, in some cases, fixing iron brackets for supporting the seat independently of the basin. Failing this, the joint should be made so elastic that any slight movement will not injure or break it. In conclusion, it only remains to be said that this kind of joint, even when well made, cannot be accepted as being a reliable one under all conditions.

Amongst the rest of the improvements that have been made in the jointing between earthenware traps and leaden soil-pipes is one in which a brass socket is soldered onto the pipe. If the reader refers again to Fig 456, and assumes that the socket is made of brass and is soldered onto the lead-pipe, as shown by dotted lines, he will understand this. The annular space is partly filled with asbestos, or other suitable material, well caulked, and then flushed up with Portland cement. This joint is considered to be a very good one by some engineers, but it is an open question if its rigidity is not rather a drawback. Some little time ago a case came under the writer's notice where the W.C. traps were broken owing to the connection to the soil-pipe being inflexible. These joints were not quite like those above described, but similar, in so far that they could not move. The basins stood on concrete floors, and the joints to the branch soil-pipes, which were lead, were made to allow for a slight movement; but the bricklayer, when making good the holes in the brick walls behind the basins, had solidly built them in. The plumber, when fixing the W.C.'s, used some carpenters' nails as wedges under the foot flanges, when levelling the basins, to hold them steady until they could be properly bedded. These nails, some time afterwards, rusted with such violence as to lift the basins bodily, and the traps were broken across the centres or highest parts of the traps. Of course, the plumber should not have used nails, but it is probable that wooden wedges would have had the same effect. Another experience which does not quite apply to our present subject, but may be mentioned, is

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where, out of about 30 pedestal W.C.'s, eight were broken across the top parts of the traps, owing to a bad kind of Portland cement being used for making the joints to the traps and bedding them on concrete floors. These experiences lead to the conclusion that frail pieces of crockeryware, such as W.C. basins, should not be too rigidly fixed, so that they cannot move without being so strained that they become fractured.

Another kind of slip joint that has been tried is shown by Fig. 458. In this case the end of branch soil pipe, which is of lead, enters an inch or two into the outlet of the earthenware trap. A leaden cap is soldered on to pass over the outside of the trap. The bottom of the annular space is filled with cement and the trap then pushed into its place. At first sight this will appear to be a good joint, but it is not so. The edge of the end of the inner pipe meets the current, of what passes through, thus forming a check in addition to reducing the waterway. Any little defect would allow the water to escape, as shown by the arrow, although this would not be the case if the joint was upright. When inside the house an escape of air at this joint would, in some cases, be a serious matter.

Several mechanical joints have been invented by various manufacturers. Figs. 459 and 460 are examples of two of them. The first one has

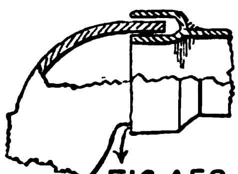
FIG 458

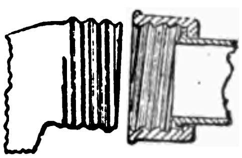
FIG 459

a screwed thread made on the end of the trap. A hardened-lead cap with an inner lead lining, can be soldered to the branch lead soil pipe, is screwed onto the trap and it is claimed by the inventors that a thoroughly reliable joint can be made by this method. Fig. 460 is a flange connection. One half of the metal flange is cemented onto the trap, the other half is soldered to the lead soil pipe, and the whole bolted together with nuts and bolts. These are both new inventions. The writer has not had any opportunity of watching if they fulfil all that is claimed for them, or if they have been in use long enough to warrant him expressing any opinion upon their merits.

Fig. 461 is another mechanical joint. On the outlet of the earthenware trap a very strong flange is moulded. The end of the lead soil pipe has a strong metal ring passed over it and is then flanged outwards. The ends are then fitted together and fastened by means of metal clamps and screws. Between the flanges a vulcanised rubber ring is placed, the whole making a very strong joint which allows for a certain amount of movement by reason of the flexibility of the ring. It has been urged that the ring, being made of perishable material, will eventually deteriorate and decay, but the writer has never come across such a case.

All the joints that have been referred to have been sloping or nearly horizontal, but there are several W.C.'s with the outlets of the traps look-

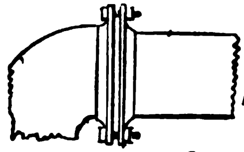
FIG 460

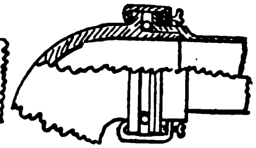
FIG 461

ing downwards — Figs. 452-3-4 and 5 are examples. All the joints shown by Figs. 458 to 461 can be adapted to the latter cases. In addition, joints, as shown by Fig. 462, are sometimes made.

A has an earthenware flange on the trap, which is similar to that shown on Fig. 455. This has an indiarubber ring, or a bedding of oil cement, under the flange which is fastened to the floor by means of screws or wooden cleats, as shown in the figure.

B has a socket worked in the end of the lead soil pipe. The top edge of the socket is bossed over the flange, which is first bedded in lead cement.

C has the end of the lead soil pipe projecting above the floor and the outlet end of the trap enters and passes over the pipe a short distance. The trap having a groove in the end as shown in the sketch section.

D has a properly prepared socket worked on the end of the soil pipe, as described for Fig.

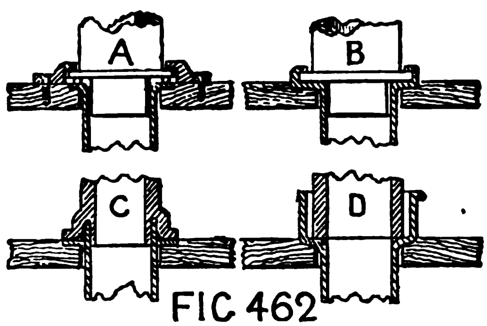

FIG 462

456, and the annular space between the trap end and socket is packed for a short distance with suitable material and then filled up with a specially made elastic cement. We need not refer to any more of these joints and the writer does not care to comment on them. It need only be stated that the inventor of each one lays claim to its efficiency.

In addition to the remarks that have been made on "washout" and "washdown" closet-traps, there is still a very important one—

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namely, the difficulty of getting them with a proper water-seal. These traps should have not less than 2 in. dip. That is, the "dip" should be immersed in the water 2 in., so that that quantity must be syphoned or evaporated out of the trap before drain air can pass through,

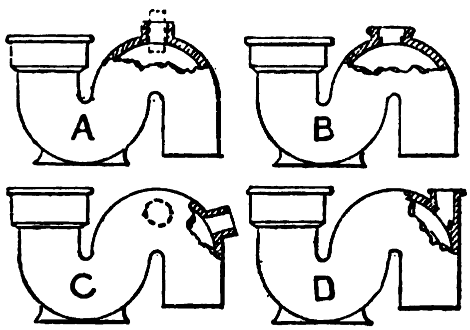

FIG 463

But with this water seal it is more difficult to drive paper and other matters through the trap, hence makers do not agree with the writer on this point, but make the dips less than stated. The writer has found traps to have no seal at all and, when testing drains by that means, smoke pass freely through them. Such a case occurred this week. Scores of traps are found with only $\frac{1}{4}$ in. and $\frac{3}{8}$ in. dip. The makers are not entirely to blame for this as there are great difficulties in making earthenware traps to an exact shape, owing to the unequal shrinkage when in a clay state and the distortion that takes place when being fired in the kilns. These evils are aggravated by careless workmen fixing the traps out of level or with the outlets drooping downward, so that less water is retained in them. A great many of the "washout" W.C. traps are not made so neatly as shown by Fig. 452, but have corners in the crown of the outgo, which never get scoured sufficiently to keep them clean.

The shapes of a great many earthenware W.C. traps are bad, not only in construction but in design; that is, when they are designed. They are not only out of shape, owing to the changes that take place during the process of being made, but their form is far from being good. It seems a pity that when a maker designs a trap that looks well on paper as a drawing, and would, perhaps, answer satisfactorily in use, that he does not put in the market the actual goods that he illustrates in his catalogue. Some do this, and I say it to their credit; but there are others who do not, and who send out everything that comes out of the kiln, so long as it is not actually broken. All that we, as plumbers, can do is to carefully examine such fittings before fixing them, and exchange those that are not as they should be. For what constitutes a good trap, and also for the various objectionable details in some kinds of traps, the reader is referred to previous lectures, where about fifty-four examples were illustrated.

Now for a few words on the vent arms to earthenware W.C. traps. Only a very few makers ever give this, apparently trivial, item any thought. Fig. 463, shows a few examples of those often met with. A, is the commonest. The position of the arm is wrong, and water passing through the trap will splash up the arm and eventually choke it up. Neither is provision made for preventing the lead pipe projecting downwards, as shown by dotted lines, and thus forming an obstruction to passing objects. B, has the first objection, as described for the last trap, but the lead ventilating pipe-end fits into a socket and cannot enter inside the trap. C, is worse than either of the two preceding examples, especially when the lead ventilating pipe is attached in a horizontal direction, so that what gets inside will not run out again. With a great many W.C.'s, especially of the washout kind, the arm cannot be fixed in any other position without being brought too prominently into view. Some may think that if the arm was attached, as shown by dotted lines, it would be an improvement; but this could only be adopted with some and not all kinds of traps.

D is another example, which is better than any of the others. The only objection is that with a great many W.C.'s the ventilation pipe comes in the way of the service pipe to the arm of the basin, but this can be got over by having the arm fixed as shown by dotted lines. Another detail in connection with earthenware traps for W.C.'s, when the basin and trap are in two pieces, is the joint between them. Fig. 464 is a section showing a joint of an improper kind. The bedding cannot be properly done unless the plumber passes his hand through the basin and pushes some oil cement inside with his fingers, and this is rarely done. Filth can also accumulate in the recesses just below the bottom edge of the basin. A much better joint is that shown on the W.C., Fig. 452. The joint on Fig. 453 is better still, if properly fitted. To ensure this the basin and trap should be made by the same maker, so that the spicket end of the basin is the same length as the depth of the socket on the trap, and thus ensure a close fitting joint. A properly made trap will cost from ninepence to a shilling more than those commonly sold, and to save this small amount unscrupulous people will sometimes buy a good basin at one place, where only good things are sold, and then buy a cheap trap at another house of business. There is no doubt that in these days of keen competition things are often done which would not be under other conditions. Another evil is shown by Fig. 465. When making sanitary surveys the writer often finds this arrangement. An engineer, or an architect, will condemn a common long hopper basin, and order one of a better kind to be fixed. The basin is removed and a piece of stoneware drain pipe fixed to the old trap, the

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new and improved kind of basin fixed as shown in the figure. The basin, as seen by the engineer, appears to be all right, but if he omits to look below, he will not discover that his intentions have not been carried out to the full extent. The long length of pipe between the basin and trap will get very foul inside, and cannot be kept clean unless it is scrubbed daily by means of a brush.

We may now leave W.C.'s with earthenware traps by remarking that they are often preferred owing to their being strong enough to bear the weight of the basin and user without collapsing.

We will now refer for a moment to the greatest objection to the W.C.'s we have been discussing, namely, the joint to the soil pipe when fixed upstairs. Most of our leading engineers know the evils that have been enumerated

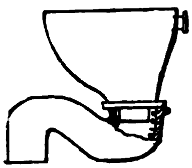

FIG 464

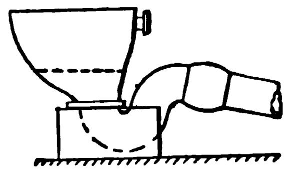

FIG 466

and stipulate that the traps shall be made of lead. Soldered joints can then be made, and the material being of a soft, in distinction to brittle, nature will not break in itself by any slight movement that may take place. But, owing to the softness of the lead, supports have to be fixed to bear the weight of the basin and seat. Various methods have been tried with this object. Several years ago the writer fitted them as shown by Fig. 466. A wooden box with three sides and a top was made. A hole was cut through the top, the hole being rebated all round about ½ in. deep, and the box being placed in its position, the trap was then flanged over and the basin bedded down as shown in the figure. This would not do with a rim seat, owing to the liability of its pressure moving the basin and spoiling the joint to the trap. A wrought iron ring with legs was also tried, but this was no better than the wooden box. Basins were also made without a flange to the base, and embedded in bossed lead seatings soldered on to trap on the top of the box, the seating extending up the basin as shown by dotted lines. This made a stronger and better job, but looked unsightly. Strong cast iron brackets, horseshoe shaped, were also made, and cut and pinned to the back walls of the closets. The traps and basins were then fixed on the brackets in a way similar to those on the wooden boxes.

During these last few years great improvements have been made in this kind of W.C., and several makers now manufacture them with lead traps, especially fitted to the earthenware basins, and in such a way that any unsightly parts are hidden from view by the earthenware, either in the form of the basins or by means of

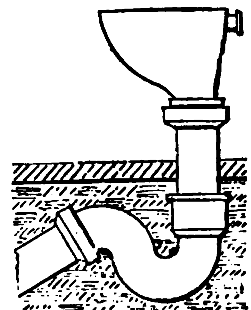

FIG 465

earthenware screeners. Objections have been made to the dark appearance of the inside of the lead traps as seen at the bottom of the basins. To hide these, earthenware linings have been inserted in the visible part of the traps. There is not the least doubt that the appearance is improved by this, but it is an open question if, from a sanitary point of view, the principle is good, or if there is a liability of the linings being broken, and, by falling or being washed into the soil pipes, form stoppages.

It is unnecessary to say anything about the evils of having access caps to earthenware W.C. traps, as this was referred to when writing on lead W.C. traps.

Before describing any other kinds of W.C.'s, we will deal with the methods of flushing those that we have had under consideration.

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FLUSHING WASHOUT AND WASHDOWN W.C.'s.

WHEN washout or washdown W.C.'s are used they are generally flushed by means of small cisterns, holding from two to three gallons of water each, and an arrangement of valves or syphons for emptying them into the W.C. basins. The sizes for the pipes from the cisterns to the basins are generally guessed at. Because of this want of thought, or study on the matter, a great many that would otherwise be good W.C. basins are condemned as being bad, owing to their not being properly flushed. In the endeavour to well-flush a basin a pipe which is much too large is frequently used. The result being the basin is "flooded," which is quite a different matter to "flushing" it. Some of the contents of a W.C. basin are very buoyant, and will float on the surface of the water. These buoyant matters have to be forced through the trap by the water flush. If this is too violent the water will stand higher in the basin during the time the flush is in action, floating matters will dance about on the surface and remain in sight in the trap after the flush is spent and the water has subsided to its ordinary level. To thoroughly flush a basin a certain quantity of water is necessary, and the time occupied by the water in passing through the pipe into the basin should be considered. Assuming a flushing-rim washdown basin to be flushed with 3 gals. of water in two or three seconds. In a great many instances a piece of crumpled up paper thrown into the trap would not be carried away by the flush, but would remain floating to the last. Whereas, if the same quantity of water was made to pass through in a more extended length of time a depression would be made in the surface of the standing water in the trap, in some cases a slight vortex would be made, and the paper being drawn into this would be below the incoming water, and thus get pushed through the trap. The shapes of basins and traps vary very much indeed, but as an average, we may assume that with a 2 gal. flush, four to five seconds will generally clear the contents through the trap. With a 3 gal. flush, six to seven seconds should be occupied, and a lesser length of time would not be so satisfactory in results. On the other hand, a mere dribble of water, no matter how much the time of flushing was extended, would be of little or no use. Although the above times cannot be stated as being exact to suit all basins, we may accept them as being a fair average, and use them in the problem we have before us, and which is "What should be the sizes of the pipes between flushing cisterns and W.C. basins?"

Before we can work out the problem we must first consider at what height the flushing cistern is fixed, and also, in what position. The latter has an important bearing, as in some cases more bends in the pipes are required than in others. When the cistern is fixed immediately over the basin, as shown by Fig. 467, only one bend, namely, to the arm of the basin is necessary; but when fixed as shown by Fig 468, four bends are required. In this latter case there is the horizontal piece of pipe in addition to the bends in it, to be considered and dealt with under the heading of friction. Under the same heading we should also deal with the retardation of the velocity of the water when passing through the valves or syphons in the cisterns. With regard to the bends in the service-pipe, if they are made to a radius of not less than five times the diameter of the pipe, as shown by

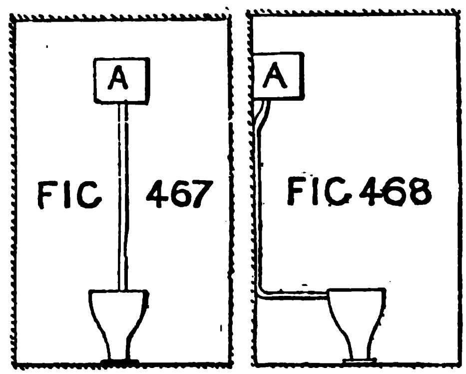

Fig. 285, the friction is reduced almost to that which takes place in a straight piece of pipe of the same length. It is impossible to state what is the exact amount of friction that occurs in short pipes with bends in them, and including that in the other parts of the flushing arrangements to the W.C.'s. The difficulty is added to from the fact that there are never two problems that are exactly alike. But we can, for our present purpose, assume that the actual velocity of water flowing through such pipes and flushing arrangements is about 75 per cent of the theoretical velocity when passing through a straight vertical pipe of the same size. That is, if there were no friction, the amount of water discharged from a pipe in a given time would be represented by 100, but by reason of friction it is reduced to 75.

The theoretical velocity of water passing through straight vertical pipes is equal to that of falling bodies, and is governed by the height from which it falls. The rule for calculating this is V=theoretical velocity in feet per second. and $V = 8{\cdot}025 \sqrt{H}$. To explain this, we

will work out an example. If the level of the water in a cistern is kept constant, that is, at the same level, and a vertical pipe from the cistern was 5 ft. long, measured from the surface of the water in the cistern, we should then have what is called a 5 ft. head of water. Then $H=5$ and $\sqrt{5}=2{\cdot}236$. Then $2{\cdot}236\times8{\cdot}025=17{\cdot}944$. For simplifying our working, we may call this $V=18$. This represents the theoretical velocity in feet per second at which the water escapes out of the end of the pipe. But for reasons above given, we must make deductions and multiply the theoretical by ·75 to get the actual discharge. We then have $18\times{\cdot}75=13{\cdot}5$ as being the velocity in feet per second discharge from the pipe. To apply this to the required size of pipe for flushing a W.C. In this case we should have to measure from the middle of the flushing cistern, and this would be considered as a mean of the level of the water, owing to the head being lowered as the cistern emptied. In this case, too, we can assume the head of water as being 5 ft., the flushing cistern as holding 3 gals., and the flush to last six seconds. To find the diameter of the pipe to fulfil these requirements we first take the velocity of discharge in feet for one second, which is 13·5 and multiply this by 6, the number of seconds the flush is to last, and we get 81. This represents a column of water 81 ft. long, but of an unknown diameter, and the total quantity of which is 3 gals. Now, 1 gal. of water is equal to 277¼ cubic inches, and 3 gals. are equal to 831¾ cubic inches. If we reduce the 81 ft. to inches we get 972. We now divide $831\frac{3}{4}\times972$, and we have ·8557. This being the area in inches of a cross section of the column of water. The square root of this is ·925 in., and this represents the length of the side of the square column. To reduce a square figure to a round one of equal area we multiply by 1·1283. So now we have $1{\cdot}1283\times{\cdot}925=1{\cdot}04367$, or a trifle over 1 in., which is the diameter of the pipe. In practice, a pipe 1⅛ in. in diameter is found to work very well, but the flush is not quite so long as the time given in our problem.

If a larger or smaller quantity of water is used, if the time of the flush is too quick or too slow to suit the basin and trap, if the cistern is fixed higher or lower than the problem we have worked out, the same rules apply, but the figures have to be changed to suit the circumstances. It must be clearly understood that we have dealt with the problem of sizes of W.C. flushing pipes in an approximate manner. Those readers who wish to be more exact had better consult the formulæ given in the various text books on hydraulics which are much too cumbersome for many students who have a difficulty in working them out. Below is a table of sizes of pipes for flushing "washout" or "washdown" W.C.'s, under various heads, which have been worked out for use in practice, and which have been found to answer fairly well.

Table of sizes of service pipes for flushing washdown W.C.'s under different heads of water to discharge 3 gals. in five seconds.

Head of water in feet.	75 per cent of theoretical velocity in feet per second.	Internal diameter of pipe in inches.	Size of pipe to be used in practice to ⅛ths of ins.
3	10·4	1·30	1⅜
6	14·7	1·06	1⅛
9	18·0	0·99	1
12	21·0	0·916	1
15	23·2	0·868	⅞
18	25·5	0·83	⅞
21	27.5	0.80	⅞
24	29·4	0·77	⅞
27	31·3	0·75	¾
30	33·0	0.73	¾

We may now refer to the various methods for flushing washdown and washout W.C.'s. These may be divided into two sections, namely, valves and flushing cisterns. The latter section to be again divided into those which give an unlimited supply and those which discharge a limited quantity of water. We will deal with valves first. It would be a waste of time to dwell upon valves of the ordinary "stool cock" pattern, and we can dismiss them with the remark that they are nearly always useless for their intended purpose. A good kind of valve should have a waterway through it equal to the sizes of the pipes given in the preceding table, and the waterway should be the *actual* and not merely the *nominal* size. Very few valves are sold that are the actual size by which they are described, and a great many have such tortuous ways through them that not nearly so much water will pass through as with others that are properly made. Valves sent out by most of our good makers have arrangements attached, or form a part of their construction, by which they close slowly, and thus allow a certain quantity of water to pass after the handles have been liberated. This is a great advantage, as people will frequently be in such a hurry that they will not hold the handle up long enough to thoroughly flush a basin. An ordinary valve, with bellows regulator attachment, is shown by Fig. 469. When this valve is used the pipe is usually connected with a large cistern, and water will run so long as any remains in the cistern, provided the handle is held up. This is a very good arrangement, but only applicable where the W.C. basins have enclosed seats to them. In cases where the same cistern holds water for drinking purposes, in addition to flushing W.C.'s, it is usual to fix a small intermediary cistern for the W.C., so that by no manner of means could contamination of the drinking water take place through any pipe communicating with the W.C. By some, this is thought to be impossible, and is only a fad, but to prove its importance a few examples of water pollution by this arrangement will be given at a future time.

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Instead of the bellows to regulate the closing of the valve, as shown in the last figure, some makers have a second chamber in which a small valve and piston works. The small chamber fills with water when the handle is raised and the flushing valve closes at the same speed as the water escapes out of the small chamber. The water which runs after the handle is released is called the "after-flush," and in some cases is very valuable. For instance, if a syphonic action sets up during flushing, and partially empties the trap, the

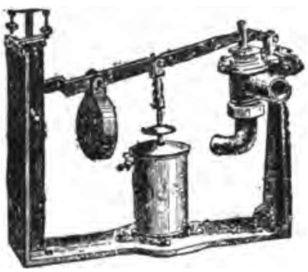

FIG 469

after-flush will recharge it. The flush alone will rarely start a syphonic action on a W.C. trap, but if an excess of paper has been used, the trap will become blocked until sufficient weight of water has accumulated in the basin to force the paper through the trap, and by filling the outlet start the action described. Such does frequently occur, hence the the value of an after-flush. Another advantage of the valve and regulator is the shortness of time between raising the handle and the commencing of the flush. This will be referred to again when we deal with valve W.C. apparatus. It is sometimes claimed that with this means for flushing W.C.'s, the pipe is always full of water, and thus becomes useless when frozen. This is only a superficial argument, because when the water in this pipe is frozen it is also in a similar condition in the cistern, and often so in the W.C. trap, especially when fixed above the floor and similar to those under review. In a great many country places the old-fashioned round valve and service box fixed in a cistern is still looked upon as being a very good arrangement. And so it is, provided the valve is a large one, the service box of a good size, the down pipe of a size according to the preceding table, and fixed as close to the W.C. basin as possible, so that the water will come quickly after pulling the valve open, and, lastly, if people could be persuaded to hold the pull for about five or six seconds, instead of just jerking at it and then running away. The old-fashioned small spindle valve fixed on the end of the pipe in a cistern is a very toy-like arrangement for flushing W.C.'s, and ought never to be used.

To write a full description of all the methods practised for flushing washout or washdown W.C.'s would occupy some years, and I do not think it necessary to weary the reader with more than two or three more examples. The first one will be what is generally known as a "water-waste preventing cistern." One water companies' manager, that the writer knows, rightly calls them "water-wasters," from the fact that they are so often out of order that they waste a great deal of water. Fig. 470, is a section of a very commonly known description, and is fixed as shown at A A, Figs. 467 and 468. The construction is as follows. A small cast-iron, wrought-iron, or zinc cistern, holding together about 3 gals, is divided into two parts. The larger one, B, is the flushing part and holds 2 gals. of water, which is emptied by means of the valve, C, when the handle, D, is pulled down. This chamber is filled by means of the ball-valve, E. The stem from the valve is connected to a ball, F, which floats in the smaller chamber, G. The valve, H, is to allow the water in G to pass to B. The action is as follows. When out of use the two chambers fill simultaneously, the valve, H, being open and C closed. On pulling the handle, D, the valve, C, is opened and G closed. This retains the water in the small chamber in which the ball floats and prevents the ball-valve opening, so that no water can run in until the handle has been released. On doing this, the weighted lever to which valves C and H are attached, falls back to its original position, reversing the

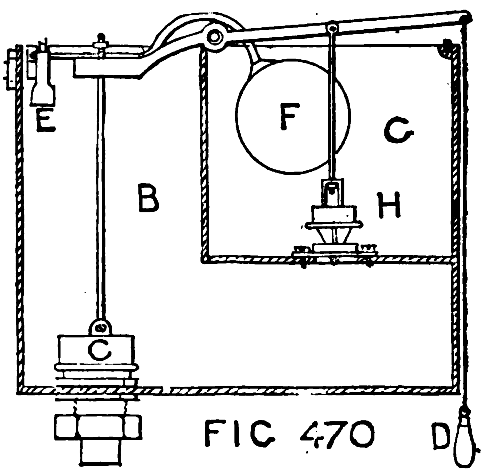

FIG 470

opening of the two valves and allowing the water in G to pass into B. At the same time the float falls and the ball-valve opens and refills the two chambers ready for the next flush. Sometimes the valve, H, will get jerked out of its position, and, although water companies' officials may object to this, in that case a 3 gal. flush can be had instead of the 2 gals. There are several objections to this kind of flushing cistern, one being the number of valves, which

are liable to get out of order; and another, which is the most important of all, arises from visitors to the place being too impatient to stand and hold the handle until the whole of the limited supply of water has been used. Some will give a tug at the handle and immediately run away, so that only a very small quantity of the water comes into the basin. All kinds of W.C. basins that are flushed by this means appear dirtier than those flushed by the next kind of cistern which we will deal with.

Fig. 471 is generally known as a "syphon action" flushing cistern. It is fixed similarly to the one last described, and is constructed as follows: A rectangular vessel has a pipe bent in the form of a syphon, fixed as at A in the figure, the long leg passed through the bottom of the vessel and then connected to the flushing pipe to the W.C. At B a valve is fixed for water to run down the pipe, so as to displace the air in it, and start the syphon. The valve is opened by means of the lever, C, and pull, D. The cistern is filled by means of a ball-valve, E, and ball, F. The great advantage of this cistern is, that on pulling the handle, D, the syphon is at once started, and the water will keep running into the W.C. as long as any remains in the cistern. And it is not at all necessary to hold the handle down as was described for Fig. 470.

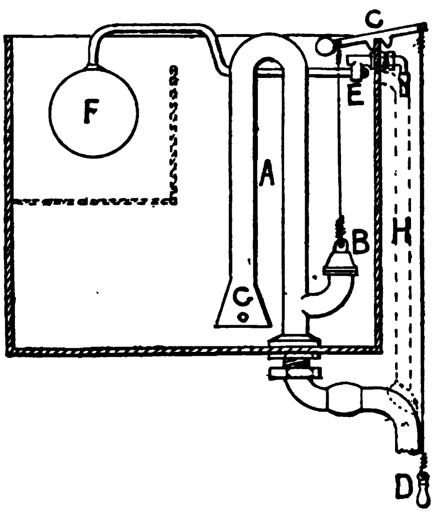

Fig. 471.

But this is not a water waste preventing cistern. To fulfil most of our water companies' or corporations' requirements the ball valve must be actuated independently of the flushing part of the cistern, and the ball must float in a separate chamber, as shown by dotted lines in the figure. This is so that if the handle was fastened to a nail, or otherwise held down, the water would not be kept running into the cistern and dribbling down the W.C. basin; the float chamber being emptied by a small syphon or through a small hole in the bottom. This is not really a water waste preventer, although accepted as being one. The syphon also would have to stand higher than the cistern sides, so that if the ball valve was defective, and leaked into the cistern, the water could not run away down the W.C. Some makers attach a sling to the lever to hold up the stem of the ball valve, so that it cannot open until the handle is let go. This is not a good method to adopt, and very few waterworks' engineers will consent to the principle. Any plumber can make up a flushing cistern, on the lines laid down in the figure, with the ordinary materials, such as pipes and valves, usually found in a plumber's shop. But a few remarks on this will be of advantage. In the first place the cistern should be made of wood and lined with sheet lead. This is much better than cast iron, sheet iron, and zinc cisterns so much used, owing to the absence of condensation on the outside of the wooden casing. With the metallic cisterns so much condensed water will drip from them on to the W.C. seats, or on to the floor, as to be very objectionable. The writer has often known men to be sent for to make repairs, the senders being under the impression that leakages were taking place in the fittings. The size of the pipe for making the syphon out of should be as laid down in the preceding table for flushing pipes, and the bend should be carefully made so as to be "clear-bore" throughout. The end of the syphon at G should be "bell-mouthed," especially when there is a great pressure of water on the ball valve. The reason for this is, when the end of the pipe is left as usually done the water will sometimes "hang up" in the end of the pipe. That is, the water inside the end of the pipe will stand a little higher than that in the cistern, and a small quantity being in the other side of the syphon, an equilibrium will be established, and remain so until the cistern is partly filled, when the syphon will start into action and empty the cistern. This is sometimes aggravated if any portion of the pipe has a bag or trap in it. This is often found in that part of the pipe which is horizontal and leads to the arm of the basin. The pent up air inside the syphon is slightly rarified or expanded, and prevents the water standing at the same level inside and outside the pipe in the cistern, with the result that before the cistern is filled to its proper height the water will run over the crown of the syphon and start it into action. To prevent this, the perimeter of the inlet end of the syphon should be enlarged to at least twice that of the pipe, so that sufficient air can enter, at the finish of the flush, to thoroughly break the syphonic action. When there is a great pressure on the ball valve, the water will sometimes come into the cistern almost as quickly as the syphon will discharge it. Not that the water is continually running away. To use a common expression in these cases, the syphon "picks up," and when the cistern is partly filled will start automatically

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into action. The writer has known this to go on for several days without intermission. Some plumbers will make a "snort hole," as shown by a small circle near the bottom end of the syphon inlet leg, but this is rarely found to be efficient owing to its not being large enough to allow sufficient air to enter in the second or so of time that the action is taking place. Other plumbers will fix a small air pipe to answer the same purpose, but the bell mouth is better than anything else that has been tried. All syphon action cisterns are very noisy when in use, and the noise generally increases towards the end of the flush. Several patents have been taken out to prevent this, but very few fittings that are made are really noiseless, although that claim is made for them. The bell-mouth at the end of the syphon is also an advantage for the prevention of this objectionable feature. When an excessive pressure is on the main service pipe the ball valve should be made to suit it. That is, the valve should have a reduced waterway, so that the water would not enter the cistern so quickly that the syphon would not stop working. On the other side of the question, under a low pressure a "full way" ball valve should be fixed, so that it does not take an unreasonable time to fill the cistern. Where a W.C. is frequently used, and people come and go in quick succession, it is important that the basin should be left clean after each usage. This cannot be unless the flushing arrangements are in perfect order.

With regard to the overflow pipes from flushing cisterns, they should always be taken out of doors, the same as for any other cisterns, and made to empty in the open air. They are sometimes found to be connected to the soil-pipe or W.C.-trap. They have also been found connected to the down service pipe to the W.C., as shown by dotted lines at H, Fig. 471. None of these methods should be practised. In the first instances given we should consider them as being unsanitary, and in the latter the syphon would not work properly if air was admitted into it.

Fig. 472, is a section of a valve which is sometimes fixed in flushing cisterns. It is called a "waste preventer," and is very simply constructed. The valve itself is like any ordinary cistern valve, excepting that an indiarubber cup fits over it, and a metal weight, concave on the under side, fits over the cup. On pulling the handle the weight and cup are raised, but owing to a vacuum being formed under the cup the valve is raised also. A small hole made through the cup allows the water to get inside, and thus break the vacuum and allow the valve to drop onto its seating. Those readers who have not outgrown their memories of boyhood will call to mind the round piece of leather, well wetted, and with a piece of string through the middle by which they lifted pieces of stone or other weights. The principle of the valve, shown by Fig. 472, is that of the piece of string and disc of leather. The advantage of this valve is that, unless tampered with or injured, it cannot be left open for water to run to waste. Where the syphon cistern, shown by Fig. 471,

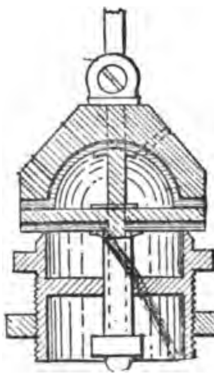

FIG. 472.

has to be converted into a water waste preventing cistern, the waste preventer valve is fixed instead of that shown at B.

Fig. 473, is a very good syphon action flushing cistern, which is patented. The drawing speaks for itself. It will be noticed that there

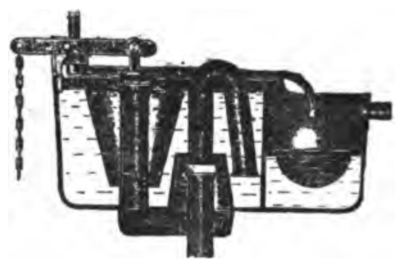

FIG. 473.

is no valve for starting the syphon, and the ball-valve does not begin to close until the flushing chamber is full to overflowing. The overflow from the latter chamber empties into the smaller one in which the ball floats. By this arrangement the cistern fills much quicker than by the ordinary methods as usually practised.

Another flushing cistern which is very simple in its action is shown in section by Fig. 474. The writer made drawings and models of this a great many years ago, but it has since been patented by another person. Instead of a valve to start the syphon a "displacer" is fixed. This is simply a copper cylinder, filled with air so as to float, with a tube through the centre to fit over a pipe fixed to the bottom of the cistern. A rod, or chain, with a handle at the bottom end, passes through the pipe and is connected to the top of the cylinder. On pulling down the handle the cylinder is forced further into the water, thus raising the level sufficiently to start

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the syphon. This cistern has both good and bad points, which it is not necessary to refer to. Neither need we give any more examples of the subject we have been dealing with. Those that have been referred to were selected from some hundreds, with the sole object of illustrating the principles which govern the working of the

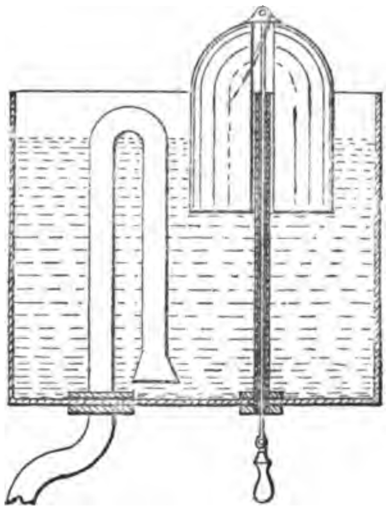

FIG. 474.

majority of the flushing cisterns that plumbers have to deal with.

We will now return to W.C.'s and dwell upon two others of an improved type that have been introduced these last few years. These W.C.'s have been designed with a view of getting a large water surface in the basins. Numbers of attempts have been made, and several patents have been taken out for fittings, to gain this object. In all cases the great trouble has been to immerse matters that floated on the water in the basins. It seems rather strange that in spite of repeated failures inventors will persist in trying to do something which is entirely opposed to natural laws. We need not repeat what has been said in earlier lectures on this question, but simply state that it is almost impossible to drive some kinds of floating matter through W.C.'s; but it is quite easy to drag them through. With this object in view a jet has been introduced into the trap so as to play beneath the water in it. When properly arranged this works very well indeed, but there is some little difficulty in finding the proper position for the jet. The idea is to set up such a strong under-current that everything is washed away, and so that the basin does not get flooded with water from the flushing rim. The modern W.C.'s that we will now refer to depend upon a syphonic action for gaining the same object.

Fig. 475, which, by-the-by, is not modern, as the writer fixed them about twenty-five years ago, is a section of the basin and trap. As seen in the sketch the surface of the water is much larger than usual, and is also of a good depth. The basin and trap were made in one piece of

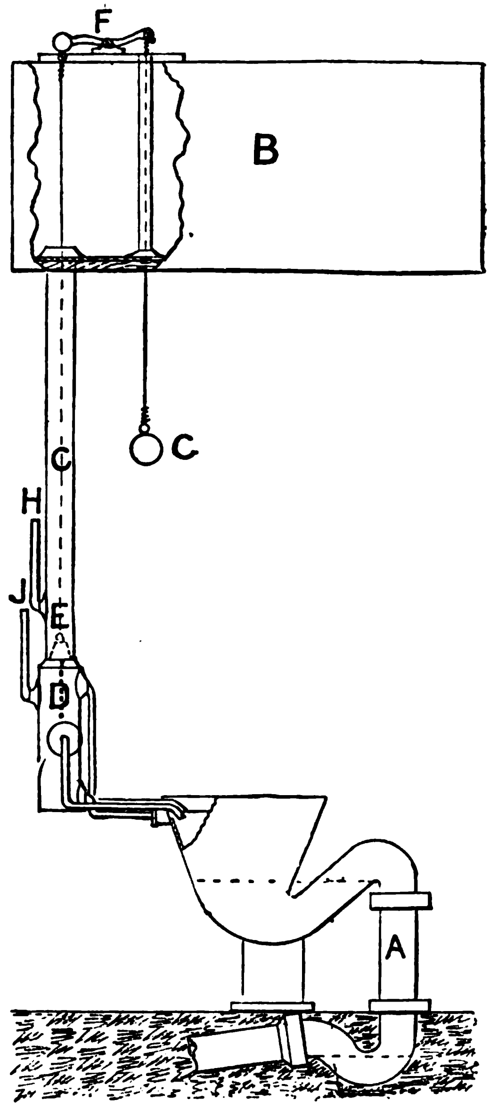

FIG. 475.

ware, and a piece of pipe, A, in the Fig., rectangular in cross section, from the outgo of the trap, was connected to what at first sight appeared to be a second trap, but was not so. When the basin was being flushed the first portion of the water that passed through the trap fell into the lower bend and just sealed it sufficiently to prevent all the air in the pipe, A,

escaping down the drain. The air being pent up as described, the contents of the basin headed up a few inches until there was sufficient pressure to drive the air out and through the lower bend. A syphonic action at once set up and emptied most of the contents out of the basin. The flushing arrangement at this stage increased in force and completely emptied the remainder of the water out of the trap, and after a pause of about half a second an after flush came down and recharged it. The flushing arrangement consisted of a cistern, B, a 3 in. lead pipe, C, soldered to the bottom of the cistern, and to a 4 in. leaden pipe, D. At E., on the top of the latter, a brass valve, with a very long spindle, was soldered, the valve being lowered down through the pipe, C, and worked by means of wires, ball-lever, F, and pull, G. Three ¾ in. pipes were soldered to the pipe. D. One of these was connected to the arm of the flushing rim of the basin, and another acted as a jet onto the water in the trap. The third pipe was for emptying the contents of D, for the after-flush. One acted as an air-pipe when the valve was closed, to let the after-flush escape; all the pipes acting as flushers when the valve was open. The writer will never forget the first one he fixed, owing to the great difficulty he had in preventing the noise made by the chattering of the valve, E. When started there was no means of stopping it until the cistern, which held about 100 gals., was emptied. Several days were spent in experimenting, but success was gained at last by fixing pieces of ¾ in. lead pipe, as air-vessels, as shown at H and J. As a W.C., the whole arrangement was a success; but it was not safe

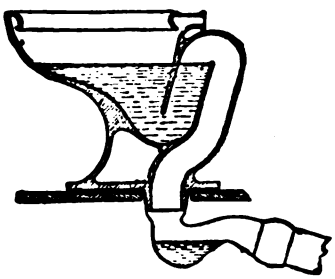

FIG. 476.

to use it for slops, owing to the risk of being left without sufficient water in the trap if the user failed to pull the handle afterwards.

Fig. 476 is of more recent introduction but has several points in common with the last one described. The writer has seen this in use as a W.C. and thrown bronze coins and other matters into the trap. These have been washed through by the flushing arrangement and syphonic action combined, nothing being left in the trap excepting clean water from the after-flush. The trap is in sight, obstructions can easily be removed and it is so arranged that there are several inches of water seal. This is an advantage in that it takes longer for the seal to be broken, by the evaporation of the water, as was mentioned further back in these lectures, and also ensures fæcal matter being thoroughly immersed when the W.C. is in use.

Fig. 477 is a still later invention and has a great many good points. The depth of the standing water and the area of the surface are much larger than in most of the ordinary W.C.'s of the washdown kind. The depth of the water seal is also much greater and will resist being broken by evaporation for a much longer period of time. Ordinary water flushes would

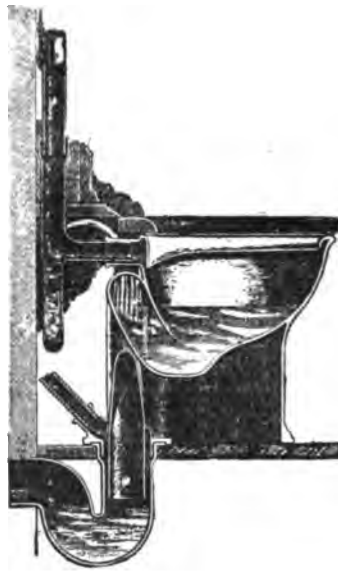

FIG. 477.

not clear the contents out of the trap, but by applying natural laws to the method of flushing perfect success is gained. In an earlier lecture, on trap ventilation, stress was laid on the importance of the atmosphere pressing equally on the two water surfaces, on each side of the dip of the trap, so as to keep the water in a state of equilibrium, and by reducing the air pressure on one surface the other one was depressed, in some cases the water being pushed through the trap by this pressure. In the closet we are describing this principle is applied as an aid to the flushing arrangements.

As will be seen in the figure, a jet of water discharges through the crown of the trap and creates a downward current of the air in the pipe. This partially removes the air pressure on the surface of the water, in the outlet side of the trap. The pressure on the other surface, in the basin, then being in excess, forces or pushes the contents through the trap. The air pressure alone would not do this, but the flush from the rim of the basin completes the object sought. Such is the thoroughness of the flush that a ¾ in. back nut, a small piece of brass, and a small

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bung, are all washed away by the action explained. As showing the great influence of the water jet in the outlet leg of the trap it may be stated that it is impossible to create the same action by throwing pailsful of water into the basin. No syphonic action being started by doing this.

Further back was explained some of the difficulties to be overcome when connecting an earthenware trap to a lead soil pipe. In the closet last described a second trap, made of lead, and having a soldered joint to the soil pipe, is fixed. The space between the two traps is ventilated by means of a pipe as shown in the last figure.

Before describing another kind of W.C. apparatus we will dwell for a short time on a point that is generally overlooked by plumbers and engineers. In earlier lectures, the sizes for drains, under varying conditions, were given. The construction and falls were dealt with and also special provisions for flushing described. Stress was laid on the latter, and the statement made that for "drains to be thoroughly flushed it is necessary to have sufficient depth of water in them to *float* excreta and such like matters away. . . . To make a thorough success it is important that flushing tanks should be connected to all sewage drains." In another lecture it was stated that "a scarcity or limited supply of water to W.C.'s meant foul drains and the consequent evils." Now, flushing tanks are of very great value, but when regulated to discharge only once or twice in the 24 hours the drains become very foul in the intervals owing to the W.C.'s, or the kinds of W.C. apparatus, that are used. Waste water from baths and sinks will flow away down a well-laid drain and not do much harm, if we omit that from the scullery, but the water from a W.C. is used as a motive power for removing excreta. To do this the quantity of water must not be too limited. There must be sufficient to get a certain depth in the drains to float the fæces. No one would expect a barge to float down a canal if there was very little or no water in it. But it seems to be the current idea with great numbers of people, both professional, tradesmen and laymen, that this can be done. Hence my remark above on the "point generally overlooked." Who for a moment could maintain that a "washout" or "washdown" closet basin, using two gallons of water, flushed by means of a 1¼ in. pipe, would keep the drains, even if only short ones, free from fæcal deposit? From a sanitary point of view, the above W.C.'s are of the very worst kind that could be used. It is true they, in themselves, are not so offensive (although the washout are sometimes) as a "pan" closet, but the latter is much better than the former for scouring the soil-pipe and clearing the drains, On raising the handle of a pan closet a bowl of water is instantaneously dropped into the trap below; but the quantity is too small to do much good.

We will now describe what I consider to be the best kind of water closet apparatus that was ever invented. Bramah was the inventor, and the apparatus was called a "valve closet." The title being taken from the valve used for retaining the water in the basin, and not, as generally supposed, from the valve flushing attachment. Not that the old Bramah closet is better all round than those of similar description, with improvements made in their construction. Most of the modern apparati are far better in their general arrangements, but in nearly all cases the mistake has been made of reducing the sizes of the basins. I consider that the opposite should have been done so that the usage of a W.C. would clear the drains from fæcal deposits. Or, in other words, each W.C. should have the same influence on the cleanliness of the drains as would a flushing tank. The size of the basins, and also the quantity of water supplied to them, should be increased much beyond any that are now made and fixed. Not that manufacturers of W.C.'s are entirely to blame, but rather those who are not liberal enough with their water. A large basin with limited water flush would be as great an evil as the smaller basin.

I do not forget that in some places the water supply is limited. But no sensible person would claim this as a reason for having and tolerating foul drains. If the water supply in any town, village, or mansion is not sufficient for all purposes it should be increased at all costs. There may be some difficulty in thus increasing the quantity of water, but in ninety-nine cases out of a hundred the problem is one of engineering only. If the question of cost is raised as a consideration, or barrier, it should be put on one side as trivial, and reference to previous lectures on collecting and storing rain and other waters will explain why. Not that we can always afford to ignore the question of cost, but in most cases it is the will to do a thing, and not the means of paying for it that is wanting. How is it that in most towns, with a good water supply, there is less sickness of certain kinds than we find in country mansions? In some of the latter we find either an unsuitable or limited water supply which could be increased or improved at a tithe of the cost of one picture hanging in one of the rooms, or the value of one or two horses in the stables. Where it is physically impossible to get a sufficiency of water for all purposes then W.C.'s should be abandoned and earth closets fixed instead. But where the above restrictions do not obtain and water closets are used, the flush to them should always be ample and sufficient for removing everything to the outfall of the drains. No fitting will do this so well as a valve W.C. apparatus, but to be thorough the basins should be very much increased in size, and the quantity of water in volume over what is the usual practice. On raising the handle of the W.C., the water that passes away should be sufficient to at least half

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fill the drain, and it follows that the drain should not be too large, but of a size that is half filled by the W.C. discharges.

One of the oftenest repeated objections to valve W.C.'s is their complication of working parts. If we want to gain an object it is not always wise to raise obstacles to its attainment. The working parts of a well-made valve closet are not nearly so complicated as those of some of the flushing arrangements to the so-called simple flushing cisterns. Then again, the market is so flooded with cheap, flimsily constructed, valve apparati, which are a continual tax upon purchasers for repairs and renewals, that their reputation has suffered very much indeed. In nearly all parts of the country, especially in old mansions, I am continually coming across old Bramah closets which, in spite of some 40 or 50 years of usage, are still fulfilling their purpose in an efficient manner. It would be difficult to name any other kind of apparatus that has stood the same amount of wear and tear for so long a period of time, and this in spite of their so-called complication of parts.

What is a "valve W.C. apparatus"? It consists of an earthenware basin, the bottom edge being embedded in a brass seating in which is hinged a valve for keeping the water in the basin, and emptying the contents quickly, by means of the "tumbler" attached to the axle and which is actuated by a lever with a rod and handle. The older W.C.'s were flushed by means of what was known as "valves and service boxes" fixed in cisterns immediately over them, and opened by means of cranks and wires, similar to the arrangement shown by Fig. 451. The water coming into the basin at the back and made to spread round by means of a "copper fan" or "spreader." Under the basin is a box, the older ones were made of lead, in which the basin valve worked. An overflow from the basin had a pipe, with a trap in it, which was connected to the valve box under the basin.

Before describing a good valve W.C. of modern make we will deal with a few objectionable points in connection with those of early construction, and which are often repeated in some of those made at the present day. These points may be enumerated as follows: The basins had "spreaders" to cause the water to flush around the sides; some had side arms, so that the incoming water whirled round and formed vortexes, in which cases the basins were not cleared of deposit. The outlets of some were too small, had sharp angles round them, and the basins were too much bowl shaped. When the bottom is too much rounded a portion of the flush is lost in pushing anything that may lie in the basin into the outlet opening. A glance at A, Fig. 478, will the better explain this; B showing a better shaped basin, down the sides of which fæces and paper can slide to the outlet. The overflows were much too small and would not take the water away quickly enough if the flushing valve did not close properly, but kept running for too long a time after the handle of the W.C. was dropped and the outlet valve shut. There was no special provision made for keeping the overflow trap charged with water, although in some cases the connection of the trap was made to the valve box in such a way that on pulling up the W.C. handle, some of the contents of the basin glided off the valve into the trap. At the same time some of the objectionable matter in the basin found its way into the trap and then gave off bad air through the overflow holes in the side of the basin. In some W.C.'s a tiny dribble pipe is fixed for charging the overflow trap with water. Neither was any provision made for

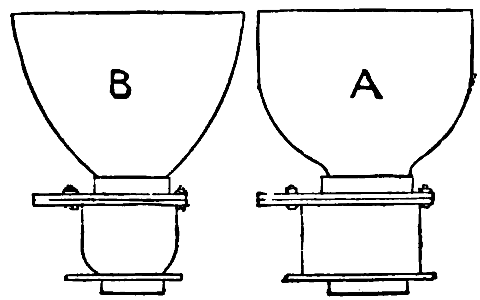

FIG. 478.

flushing out the foul contents that overflowed into the trap, nor for washing the slimy matter that adhered to the inside. There was no provision made for getting rid of the pent up air in the valve box. On pulling up the W.C. handle this air would pass upwards into the closet or be puffed out of the holes over the overflow. This was found to be particularly offensive at times, when a few days, or perhaps a few hours, had elapsed since the last usage, and more especially when the trap under the apparatus was a very large one and the water flush too limited, so that the trap was filled with sewage instead of clean water. With the service box and cistern valve flushing arrangement the water did not come into the basin immediately the handle was raised. In these cases the paper, &c. frequently got jammed between tho discharging valve and the seating at the bottom of the basin. When this occurred the water dribbled away out of the basin, leaving it empty. The sides then became dry, and when used in this condition it was very rarely indeed that the next water flush would wash off the adhering matter. A great many apparati are made with the discharging valves so badly arranged that they are nearly always becoming so clogged with paper that they cannot close properly. With some the handles had to be raised such a long distance, and the "tumblers" acted so slowly, that frequently the valves were only half opened, with the results above enumerated. Some valve W.C.'s require very

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strong pulls to raise the handles. A great many are found at the present day to be so heavily weighted that ladies, children, invalids, and other weakly people cannot raise the handles to the proper height for the contents of the basins to be properly and quickly emptied and the flushing valves opened to their full extent.

Some modern valve W.C. apparati have the traps attached to the fittings, this not being nearly so good as having the traps soldered to the soil pipe. The difficulty of making the joint between the soil pipe and W.C. trap has already been described. In some large public schools the writer examined, there were about 70 valve W.C.'s, and on applying the smoke test about 80 per cent. were found to be defective at the connection. With traps attached, the valves of the closets dip into the water and sometimes pick up paper, &c., which prevents the valve closing. With these closets the overflow arms to the basins are connected to the traps and puffs of bad air are driven out when the handles are raised.

Another objectionable kind of valve W.C. has a plunger fitting over the outlet in a side chamber. Although these fittings will stand a lot of hard wear, they are not entirely satisfactory, owing to the foul condition of the inside of the chamber after a few weeks usage. Most sanitary engineers of repute have now ceased to use or recommend so-called "trapless closets," as they are not found to be so good as was considered when they were first introduced.

We have now dealt with most of the objectionable points found in a great many old and modern valve closets. There are many good apparati in the market, but the task would be a heavy one to describe them all. An illustration of one only, which the writer considers the best of all that he has seen, or had to do with, is here given and shown by Fig. 479. We may briefly deal with the various details and take them in the same order as we did the objectionable points in some of the other W.C.'s referred to above.

The basin has a flushing rim which is continued round the overflow arm, thus flushing the basin, overflow and trap at the same time. The overflow is exposed and easily cleansed. The flush does not form a vortex, but streams down all round the sides of the basin carrying all before it to the outlet, there being no ledge on the bottom of the basin for anything to rest upon. The basin has a "table top," the combination being in one piece of earthenware. Some are made in two pieces, but these latter have frequently to be changed owing to an accumulation of foul-smelling matter getting between the basin and top. The valve box has a ventilation arm from which a pipe, shown by dotted lines in the figure, is continued to the open air out of doors. The air between the water in the basin and that in the trap is driven through this pipe when the handle is raised. Anything offensive remaining in the trap will give off bad air and this can pass through the above pipe. The connection of the vent arm to the valve box is so arranged that nothing can lodge in the end. This vent arm is kept clean inside, and any splashings washed off by the flush from the basin overflow which is connected

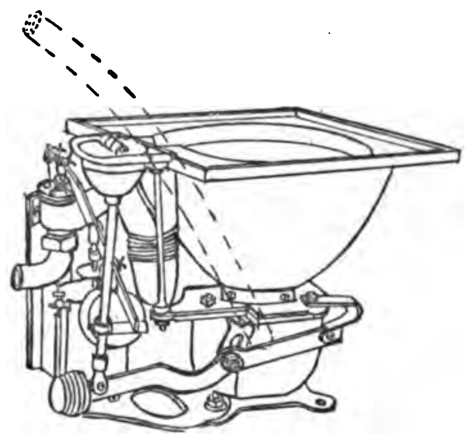

FIG. 479.

to it. No bad air can be puffed out of the overflow owing to this arrangement. The flushing valve is fixed as close to the basin as possible so that immediately the closet handle is raised the basin is flushed. This, and the way the valve is fixed, prevents paper, &c., clinging round the valve. The pull is so light that a child can easily raise the handle, and so short that the valve opens wide very quickly. The trap is separate from the apparatus and has a soldered joint to the soil pipe. The valve box is strongly made of cast iron, porcelain enamelled inside, and the valve has an indiarubber seating which can be changed or renewed in a few minutes. The top to the basin prevents slops, or an improper use of the closet, rendering the floor beneath the apparatus offensive. With this description of valve closets we can now leave this part of our subject. In response to private correspondence we will next discuss lining and covering coffins with lead.

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LEAD COFFINS.

I FEEL that an apology is due to some of my readers for rather abruptly changing the subject matter of these lectures, but so many enquiries reach me on coffin lining and covering that I feel constrained to now devote a short time to the usual proceedings of modern coffin making. We will divide the subject into three parts, coffin covering, coffin lining, and lead coffins without any woodwork. As covering coffins is the most common practice, we will deal with that first. The wooden case, or shell, is generally made of oak or elm, and, when to be covered with lead, is especially prepared by gouging grooves where the soldered seams are to be made on the bottom and ends, and by bevelling the upper edge of the lid. The lead is cut out in four pieces for covering the top, the bottom, and two sides, respectively. The weight of lead is varied, according to the class of the work, and weighs from 3½ lbs. to 7 lbs. per superficial foot. The lead should be in good condition and free from bruises, indentions, scratches, or other marks that cannot be easily obliterated by the process of cardwiring when being finished off.

The first proceeding is to open out the sheet of lead on a well swept and even floor, lay the lid on the lead and "scribe" round the edges the exact size of the lid. The lead to be cut out to the scribing and laid aside for covering the bottom. The lid to be again laid on the lead, and, with a pair of compasses set to ¾ of an inch, scribed round. The additional ¾ in being to return on the edges of the lid to which it is nailed. This piece of lead having been cut out, next measure the length of the side of the case and halfway across the ends at head and foot respectively, allowing ½ in. for lapping at the end seams. Mark this distance on the lead for a rough guide as A to B, Fig. 480. Mark the length of the piece required to cover half the head, as A to C, including the ½ in. for the seam. To the outside height of the coffin add 3 in. and mark the lead as A to D and C to E. Then mark the width of the other end of the piece of lead from a measurement taken from

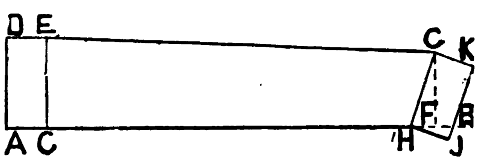

FIG. 480.

the coffin plus 3 in., as shown by dotted line F to G. With a bevel take the angle of slope of foot of coffin and mark the lead as H to G. At right angles to this line make two marks as H, J, and G K, the line J K, being parallel with H G, and at a distance equal to half the width of the sloping foot with half an inch added. Cut out the piece of lead to the outside marks, turn it face downwards on the sheet, mark and cut out the piece for the other side. The coffin to be now laid on its side on a dwarf pair of stools or trestles, and one of the side pieces of lead laid on with the ends in their proper positions, and the edges projecting 1½ in. beyond the coffin. The ends to be now dressed down and tacks or small clout nails driven in a short distance, but not up to the heads, at the edges of the lead into the groove cut into the woodwork.

Fig. 481 shows the coffin on the stools and the piece of lead laid on ready for working down the ends and sides. The double dotted lines on the bottom are the grooves cut in the woodwork for the soldered seams, which are flush when finished. After dressing down the ends, and tacking them as predescribed, work up the arrises to a fairly but not too sharp edge. Then dress down the edge on the bottom and tack it in the groove as done for the ends.

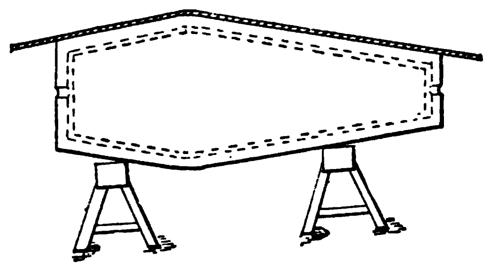

FIG. 481.

Then turn the shell on its bottom, on the stools, and dress the other edge of the lead over the top and a short distance down inside. Fig. 482 is a cross section of the coffin showing the lead at this stage of the proceedings. Drive in small tacks as near the edge of the lead as possible, as shown at K, these being driven home and are to remain. Now lay the case on its covered side, take out the nails at the ends and cover the other side as described for the first one. The coffin now to be laid with the bottom upwards and the first piece of lead that was cut out laid in its proper position, the temporary tacking nails having been first removed. Carefully flap the piece of lead quite smooth, chase the edges into the groove, and put in three or four temporary tacks in the centre of the groove to keep the lead from moving. With a sharp pointed drawing knife cut off the edges of the lead where they project beyond the centre of the groove. Some plumbers will now soil or smudge each side of the seam, but it is much better to use weak paste, made of flour and boiling water. A cabbage leaf, or a potato cut in half, rubbed over the lead will answer the

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same purpose as the paste or soil of preventing the solder tinning to the lead beyond the seam. After this protection has been thoroughly dried the seams should be properly shaved, using a round pointed hook and a straight edge to get the sides perfectly true, the temporary nails being taken out one at a time to allow the shaving to be thoroughly done. This could not be so with the nails in. As soon as the shaving has been done the permanent nails to be driven in about 2 in. apart and close to the edge of the overcloak lead. These nails must be driven tight home for two reasons, first the edge of the outer lead will curl upwards when soldering, and either show through the seam or allow the solder to get between the lap of the lead, or run beneath it; secondly, if a nail head were to show through the soldered seam the coffin would not long be air tight, hence the importance of covering the heads with solder. Some plumbers will shave the undercloak of the lap in the lead and the underside of the edges of the

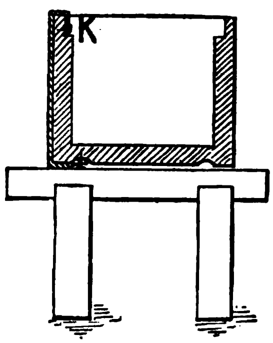

FIG. 482.

top lead, so that if by an oversight the seam should be wiped too bare the edges would be "sweated" together by the solder that was drawn or ran in between them. The permanent nails should be made of copper, and have tinned heads. For light lead and cheap work common tinned tacks are often used, and in some cases common iron clout nails. On this matter I may say that no respectable plumber would scamp his work by using improper materials in work such as a coffin, which is intended to last for an indefinite length of time.

After all the shaving and nailing has been done one of the trestles should be removed, as shown by Fig. 483, so that one end of the coffin will rest upon the floor, and the other end be at an easy angle for wiping the end seam. The board at L is for catching the spare solder. The two ends having been soldered, the coffin to be turned with the bottom upwards and the seam wiped all round. The seam for good work should never be less than 1 in. wide. The wiping cloth, about 2½ in. long, should be very thick, so that it will not bend or, when wipiug, leave the surface of the solder either raised or hollowed. Some plumbers will pack their wiping cloths, and stiffen them with a few thicknesses of brown paper, others will place a short piece of a wooden lath in the centre for the same purpose.

Men vary very much in their methods of wiping seams, but good workers pour on their solder and, when the heat is just right, will pro-

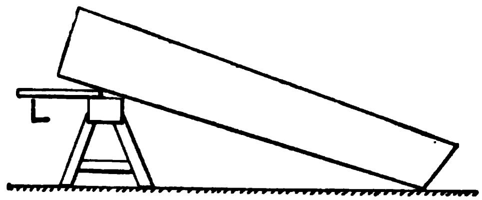

FIG. 483.

ceed to wipe at once, taking strokes of from 8 in. to 12 in. in length. The cold spare solder is left behind at the sides of the seam, and the plumber's pouring ladle kept replenished by his assistant. When soldering seams the quicker they are done the better they will look, and give lesser trouble to the plumber. If too much time is spent, if the plumber is too slow in his movements, or gets an excessive quantity of solder on his work, the lead will expand very much and so irregular that a dirty-looking uneven seam is the result.

Another way practised by some plumbers is to pour on sufficient solder for the whole of the seam and then take a heated plumbers' iron and begin wiping, keeping on until the whole seam has been done. A lesser quantity of solder is required this way than the other, but if the plumber is not very skilful the seam does not look so clean and smart. Another way, almost similar to the last, is to pour on a small quantity of solder to get a start of two or three feet, the plumber using an iron and his assistant pouring on small quantities of fresh solder from time to time a short distance in front of, or to be more exact behind, the plumber. One heated iron will be sufficient for this way of wiping round the coffin bottom, whereas, two, and sometimes three, would be necessary in the preceding way. This latter remark applies to the seams on light lead, with heavy lead more heat is necessary, that is, more heated solder or more heated irons.

A piece of pasted brown paper is generally stuck on the ends of the head and foot soldering, but a good workman can get on very well without the paper and simply rub on chalk, to prevent the bottom soldering remelting the parts on the ends that were done first. If the whole of the work is properly prepared the quantity of solder required for the body of the coffin is from 7 lbs. to 8 lbs.; but I once worked for a master who did a good trade in cheap coffins, who would allow only 2½ lbs. After completing the coffin the lid is next covered, although some men will do this first, so that their mates can be cardwiring the lid during the time the shell is being covered and prepared

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for soldering. Covering the lid is a very easy matter. The lead is simply laid on, and the edges dressed down and nailed. The whole of the leadwork is then washed clean by means of

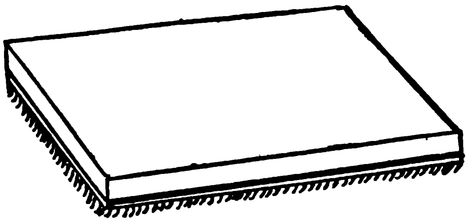

FIG. 484.

water to get rid of the paste, soil, or whatever was used as a substitute, and cardwired over. The cardwire is a piece of leather or stout fustian with wires projecting endways through one surface, thus forming a kind of brush. Second hand, or much worn, card from the cotton mills is the best, as new stuff has the wires too long, so that when using they will bend down flat; whereas the short, stumpy wires will not do so unless unfairly used. It is a good method to nail the card, the size being about 4 in. × 4 in., or 4 in. × 6 in., onto a piece of ⅜in. board, to prevent the wire loops being pushed out of the back. When mounted, the whole has the appearance shown by Fig. 484. The card, or "scratchwire," as it is sometimes called, should be used in one direction only. As shown in the figure, it would be used from right to left, in a direction which meets the bent ends of the wires. The lead surfaces are first cardwired so that the scratches are all in the same direction and perfectly straight. By the aid of a stencil plate, which can be cut out of a piece of sheet tin or a piece of thin, hard wood, or out of a piece of sheet lead, the centre portions of the bottom, sides, ends, and top, are scratched with the cardwire to what may be called a diaper pattern, as shown by the lid, Fig. 485. After the whole has been completed the coffin is then ready for use so far as the plumber can prepare it, but the lining has to be put in, and this is generally done by the coffin maker. When the whole is finished it is removed to the proper room and the corpse put in. At this point the most unpleasant part of the proceedings commence, especially when the body has swollen from any decomposition that has set up, so that there is trouble in getting the lid on. I do not care to describe what has sometimes to be done, but in cases that are not too difficult, a few heavy weights on the lid and a stout cord round the shoulder part, with a "twitch" for tightening the cord so as to pull the sides tight to the lid, have to be applied. If the sides cannot be pulled in quite tight, and spaces are left through which the solder would run and get inside, these spaces are sometimes tightly packed with paper and thin strips of sheet lead, which have been properly shaved, laid over the paper and a few nails driven through to hold the whole from rising when expanded by heat during the process of soldering.

The edges of the seam are then prepared for soldering as described for the bottom. A hole, with a carpenter's gimlet or a large bradawl, is then made through the lid. In some cases a piece of ¾ in. or 1 in. pipe is connected to this hole, by means of a putty joint, and the other end of the pipe carried through the room-window. The hole is necessary to relieve air compression, which arises from rarification of the air inside the coffin, and which would blow through the solder when in a melted condition, thus leaving small holes in it. The pipe is necessary when the state of the corpse is such that the plumber cannot work in comfort. Generally speaking, more solder is used on the lid than on the whole of the body of the coffin. The hole is soldered over after the lid is finished. As the lid has to be soldered on where the

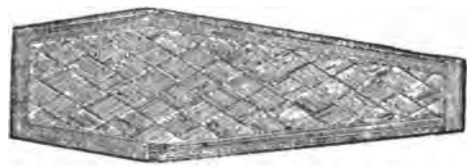

FIG. 485.

corpse lies, generally in a bedroom, there is frequently some trouble in getting a fire for heating the solder and irons, but a good undertaker will generally have a fire ready so that the plumber can quietly and decently do his work and get away as quickly as possible. The plumber should also be left alone when working. The task is not a pleasant one, and officious members of the family do not, by their presence, help to make it more so.

After the coffin has been soldered down the next thing is to place it in the outer shell, which is generally made of oak, French polished, or varnished, with the necessary handles, name plate, and other furniture. The latter is sometimes very elaborate, especially when the coffin is to be placed in a mausoleum, catacomb, or other position where it may be viewed from time to time.

We will now deal with lead-lined coffins. This plan is very rarely carried out; but in cases where economy has to be considered, the cost of one shell can be saved. The first proceeding is to open out the sheet of lead, flap it quite smooth, lay the coffin on and mark the size and shape on the lead. The coffin to be then removed, and at a distance from and inside the lines make others that are parallel with them and equal to the thickness of the sides of the coffin, plus an allowance for the lead. Outside the latter lines and equal to the depth of the coffin, measured at the various points, make the necessary marks to represent the lead to line the ends and sides. Cut out the corners and pieces at the shoulders, so that the sides and

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ends can be folded up, the whole being as shown by Fig. 486. The corners M M, must be cut to suit the slope of the foot. At N N, ½ in. to be left on the edges for folding outside the side lead to prevent the solder running through, as described when writing on lining cisterns with lead. At O O, the lead for the bottom must be cut to fit the shape of the

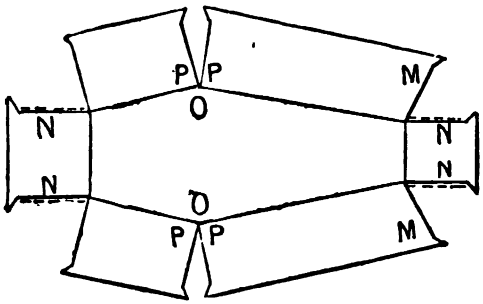

FIG. 486.

shoulders, and at P P, the parts forming the bottom of the sides must be cut straight, that is, in a line with the straight parts of the coffin. If the plumber is very careful, and cuts out the lead to the exact dimensions, he can now soil and shave the parts to be soldered before folding up the sides and ends. This is much more easily done at this stage than when the lead is placed in the shell. The lead to be then folded on the lines, which represent the bottom, the angles "set in" with mallet and dresser on the inside and then dressed quite straight on the outside. The bottom lead to be then hollowed on the under side; this can be done with the palm of the hand, and then lifted into the shell. If the lead is well hollowed, as described, it will drop to the bottom without any trouble, and on pressing down the hollow parts the angles will be pushed back into their proper places. A small flapper should now be used to flap the lead quite smooth against the bottom and sides of the shell, when it only remains to dress the lead over the top edges, chase in the upright

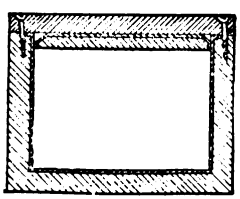

FIG. 487.

angles, either nail or punch them, put on a little touch and wipe in a similar way to a cistern or sink. A few inches must be wiped on the bottom at the points O O.

Sometimes grooves are cut in the woodwork so that the seams can be wiped flush at the shoulders. Instead of soldering up the sides at the shoulders some plumbers will boss them up. This is a good method to adopt, but takes a little longer to do. A light wooden lid has next to be covered with lead, and when in its proper position and soldered, and the outer lid screwed on, is as shown in section by Fig. 487. The lead on the top edges is let into rebates, as shown in sketch section, so that it is not seen on the outside when the outer lid is screwed on.

Another way for cutting out the lead for lining a coffin is shown by Fig. 488. Students

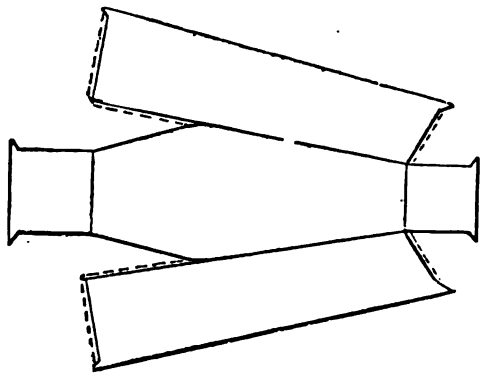

FIG. 488.

would better understand these problems if they were to cut out paper patterns, on the lines here laid down, fold them up, and thus find out the parts to be soldered.

I have never made a coffin entirely of lead, nor heard of any present-day plumber who has. Some years ago during the repairs to the chancel of a very old church, I was tempted to take off my coat, crawl through an opening in the floor, and amongst a mass of old broken stones, parts of skeletons, decayed wood, &c., eventually came across a lead coffin, which is shown by Fig. 489. The examination was made

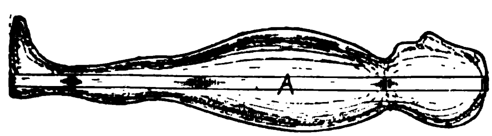

FIG. 489.

in a very hurried manner, and by means of wax tapers for light. The lead was in very good condition, and the mask worked to the features, as shown in the figure. It was evident that the lead case was made in two halves, the join being in the centre, as shown at A, but whether the seam was soldered or burnt together I could not discover. On tapping with the knuckles the sound was such as to lead one to think that the body inside was either embalmed or encased with some kind of cement. This opinion was strengthened by the fact that, although the

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figure was laying amongst rubbish and broken stones, there were no bruises or indents of any size. On sitting with the head o. the figure between my knees—I could not get at it any other way—I found I could easily lift it up. From this I judged the total weight to be about 80 to 100 pounds. I do not suppose any of us will ever be called upon to encase a dead body, but the above is interesting as showing the skill of the plumber ages ago.

LEAD BOSSING

FOR the same reasons that were given for leaving the programme of these lectures to describe coffin work, I now propose to deal with the subject of lead bossing on the class of work generally met with on roofs. Constructive lead work has been dealt with in previous lectures. To the manipulation of the metal we shall now confine ourselves. To begin with "bossing up" corners in sheet lead. It is only really first class plumbers who know how to boss up a corner. Hundreds of young plumbers make woeful efforts, slaving away, perspiration pouring off their bodies in vain attempts to do them as speedily as older men. In my own class room, and others that I have visited, I find a large class of headstrong students who will persist in making their work as difficult as possible to do. They very rarely indeed succeed in making a respectable looking corner without spending as much, or more, time in working out the tool marks as in the actual bossing. Want of thought is at the bottom of all this. Most young men are always in a hurry to begin bossing, and do so before they have properly prepared their work. As an example, we will assume a 6 in. corner has to be worked up on a bay for a lead flat. They will open out their piece of lead on a floor or platform covered with grit or rubbish, which cuts into or scratches the lead, thus injuring it, and then begin flattening it with a dresser. Probably the latter has a much worn and hollow face, so that at every stroke the lead is marked and disfigured. They then will set out their work marking the proper distances, or within half an inch or so, using a rule with the ends protected by pieces of brass by which they make the distance marks, and at the same time cut a considerable depth into the surface of the lead. If these marks come in certain positions there the lead will frequently tear. They will then get a piece of board or lath, not caring whether it is straight or not, lay it on the marks, and with the point of their pocket knife, compasses, or an iron nail, scratch the lines where the lead is to be folded. The next usual proceeding is to take a mallet and sharp chasewedge and go over the lines, cutting into the lead, thus weakening it, where it should have been strengthened. They will then pull up the sides in a slovenly way, again set in the angles, perhaps not quite on the same lines as at first and then begin bossing up the corner. By the time they have been working about half an hour the corner will appear as shown by Fig. 490. The corner at A is dragged away from its proper position owing to the absence of any stiffening creasings. The sides are so bent that the shape of the piece of work is entirely lost, and in the endeavour to straighten them the lead is contracted in some parts, thus further distorting the shape of the bay. When placed in its position it has to be re-worked and re-dressed to fit, the lead being either reduced in some parts to the utmost extent, or broken in the angles in the endeavour to stretch it to its position. Again, when bossing the corner, the lug B is left on to the very last. If the young plumber were to count the number of blows made on this lug, which is afterwards cut off and thrown amongst the lead cuttings, he would

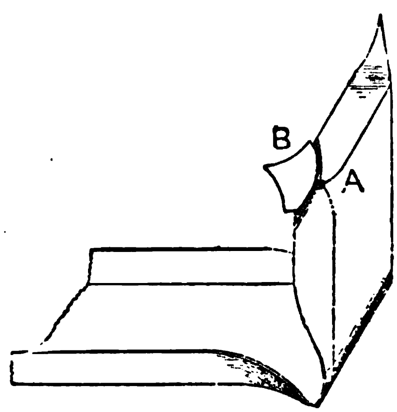

FIG. 490.

probably find that he has spent an amount of energy equal to what would have been necessary to boss up two such corners. And this without any advantage to anybody, but to his own disadvantage owing to the unnecessary strain upon his physical powers. These strictures are not intended for all plumbers, but for those who are headstrong or

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thoughtless, as the case may be, and try to be men all at once instead of slowly and patiently working their way upwards in the craft. This is the only way by which they can reach the highest pinnacle of eminence.

We need not further describe the weak points when bossing up corners in sheet lead, as usually exhibited by student plumbers, but proceed at once to describe the proper methods to be followed. In the first place it should always be borne in mind that no marks, scratches, or bruises should ever be made in the material used. When moving sheets of lead from one place to another the outer fold is frequently damaged. The damaged part, and also the corner on which the sheet number, size, and weight are stamped, should be cut off and thrown among the cuttings. The floor, or platform, on which the sheet is opened should be perfectly even, all grit and dirt carefully swept away, and if the floor is made of wood which is much worn so that the nail heads stand above the surface, these nails should be driven in with a hammer. With an uneven floor it is difficult to unroll a sheet of lead, but with an even floor the unrolling is easily done, and the lead lies so that it is not at all necessary to dress or otherwise flatten it out. As they sometimes have to stand on the lead the men should not have hobnails in their boots, and so-called steel brads are worse than nails in that they cut more into the lead. One strict foreman, under whom the writer worked some years ago, insisted upon slippers being worn because of this injury to the metal by nailed boots. After the sheet has been opened out the proper and exact sizes of the pieces should be measured on it, within half an inch or so means either a waste of material if cut too large or a spoilt piece if too small, the points made with a piece of chalk, not scratched with the corner of the rule, and a well chalked line used for marking the cutting out lines. When cutting out large quantities of sheet lead it is best to use a long handled knife, with a cord attached for the assistant to pull, as shown by Fig. 491. The cutting corners are shown square, this being preferred by most plumbers to the knife with a

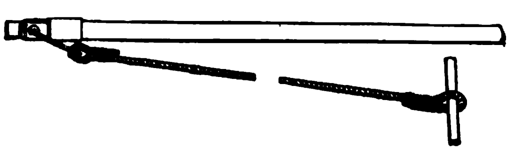

FIG. 491.

spear head point, although some men prefer the latter. The lead should be cut right through, and not just scratched on the surface. When the latter is done there is more trouble when rolling up the piece cut out and the edge is stretched. If the piece of lead is very narrow it will be found to have become bent when again unrolled prior to using, hence the necessity of cutting through the lead and thus avoiding the distortion caused by tearing when only half cut. Some plumbers will break off the piece of lead by bending it backwards and forwards on the cut lines. When the lead is to be used on a roof the pieces should be rolled up moderately tight, otherwise they will get out of shape when being moved about. Room should be left for passing a cord through the rolls either for hoisting purposes or for lifting about when on the roof.

We will now assume that the lead has been cut out and hoisted on to a roof ready for laying on a flat, that no injury to the lead has taken place, and a 6 in. corner has to be bossed up on a bay similar to that shown by Fig. 490. The roll of lead should be first opened on a flat roof (which has been carefully swept and any stray loose nails picked up), made smooth and even by means of a remnant of lead formed into a "flapper," as illustrated by Figs. 313 and 402 in earlier lectures, and then marked out to the proper dimensions to fit the intended position. This is shown by Fig. 492. The dotted lines C C and D D are 6 in. from the sides, these being for turning up against the walls; E E being 4 in. from the edge for turning over a wood roll on the flat. If the square piece at the corner, F, was cut out and the sides folded up the corner would have the appearance that it ought to have when completed. Of course, it would not be watertight, but the illustration is

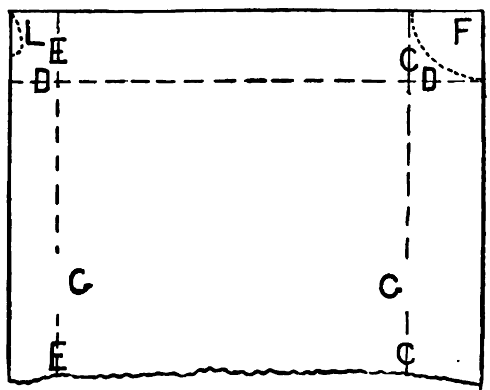

FIG. 492.

used to show that this piece of lead is superfluous. If it was cut out a corner could not easily be bossed up, and if left on more time is taken up when working, as pre-stated. In most cases the lead is so worked that the corner, when finished, is a great deal thicker than the other parts. In aggravated cases this superfluous lead is driven into such hard lumps that it is almost impossible to work them out again, or to remove the unsightly marks so as to turn out a respectable looking piece of workmanship. All this can be avoided by cutting away the lead not actually necessary. If the compasses are set to a radius of $5\frac{5}{8}$ in., and with the corner of the piece of lead as a centre the quarter circle shown at F is marked on it, the piece cut out on the line shown by the quadrant will be found to

leave more than enough for bossing purposes. In fact, when properly done, the small gusset piece left in the angle will be cut off on completion of the corner. We will confine our attention to this corner and deal with the other one afterwards. After cutting out the piece of lead lay a stout board, or a piece of deal quartering, which should be quite straight, across the sheet a quarter of an inch inside the line D D, and pull up the end of the bay until it stands upright. This should be done at one pull, and without getting it out of straight or out of shape. Then lay the quartering near the line C C, ¼ in. from it as before, the end being close to the line D D, and pull up the side in the same manner as the end. The whole of the side should be pulled up, and not a portion only, otherwise the side will not be straight. In the case of a very long bay, or a gutter, two or three pairs of hands should pull up at once, a signal being given when all are ready. If not successful the first time the side should be pushed down again and dressed quite flat, and then the pulling up repeated. It is not at all a bad plan to place a straight edge under the edge of the lead for the men to pull up, and thus ensure the stand up being straight. By placing the deal quartering a short distance inside the chalk lines they are not obliterated, and the angle to be afterwards set in is slightly hollow underneath. After the sides have been pulled up the plumber should "set them in." That is, go over the lines with a good hornbeam dresser and a heavy mallet. The dresser should be in good condition and have the setting-in edge quite straight, but the ends slightly rounded. Otherwise they will dig into and make thin places in the lead. The dresser should also be a good length, so that the setting in is quite straight and in one continuous line, instead of a series of irregular marks. Men are often seen attempting to do the setting in by means of a chase wedge. This cannot be too strongly condemned. On looking at Fig. 492 it will be noticed that at G G there are no setting-in lines shown. Of course, they would be in practice, but in this case they are omitted as the plumber should miss those parts and not set them in. The lead has to stand up for bossing the corner, and it is generally found to be convenient to fold it up, as shown by Fig. 490, the folding being done at the position where the angles are not set in, as shown at G G, Fig. 492.

When setting in angles the plumber's assistant plays an important part. He should have a "holding-down stick," which consists of a short crutch, with a notch in the bottom end. The notch being placed on the edge of the stand up lead just over the part being set in. At each stroke of the mallet on the dresser the mate pushes downwards with all his force. This aids the plumber to crease the lead without weakening it in any way. The plumber can also make a much straighter angle by the above assistance than without it. After the angles are set in the stand up sides and end should be made quite straight, the bay folded on the parts G G, as shown at Fig. 493, and the outsides of the set in angles dressed straight and to a fairly, but not too, sharp arris. This tends to thicken any parts that have been reduced in substance when setting in. Stiffening creases should now be made as shown by dotted lines. These to be done on the outside, a mallet and bossing stick being used, and the creases being about four or five inches from the sides. Those at H H can be made by means of a blunt chase wedge. The plumber can now commence

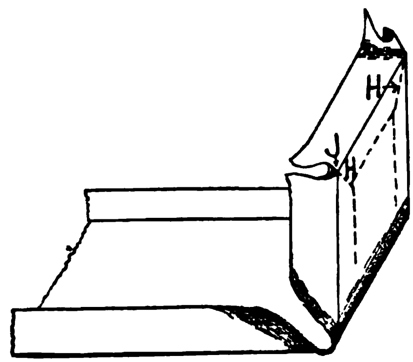

FIG. 493.

working up the corner. Most men will use a mallet for this and will hold a hand dummy inside. The latter is worse than useless, in that it marks and disfigures the inside of the corner, and the corner cannot be worked up properly by means of a mallet unless it is used sideways, or one especially made for the purpose, with a kind of blunt tomahawk head. Men who use mallets generally drive the lead into buckles and lumps and fill the corner with unsightly toolmarks. Any lead-working tool that is made of hard wood, the grain of which is used endways, wants very carefully using, and in the hands of an unskilful worker is very injurious to the lead. To boss up a corner in sheet lead there is no tool equal to a boxwood bossing stick, shown by Fig. 494. This tool is used lengthways, that is, the lead is hit with the side. It takes some little practice to use this tool properly. The beginner uses it as if he had a wooden arm, the only joint being at the shoulder. After a little practice most of the work comes from the arm below the elbow, but a skilled workman does most of the work from the wrist. Improperly used, the bossing stick makes the muscles of the arm ache very much, but with practice it is an easy tool to work with. To get on with our corner: place the left hand inside, nothing else is required, and with the bossing stick in the right hand begin tapping on the corner about half an inch from the bottom near J. The actual point where the sides and corner meet should not be touched with the tool until the corner has been bossed up and is being

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dressed straight on completion. The first few taps should be made downwards, with a tendency to drive some of the lead towards the point of the angle. The following strokes of the bossing stick should be towards the left

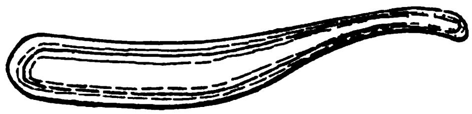

FIG. 494.

hand in a direction as if the lead was being dragged on to the left wrist. During the whole time when working the corner the sides must not be allowed to open out. After some little time has been spent on the work the corner will appear as shown by Fig. 495. If pains have been taken with the working, the corner, so far as it has been done, will not have any tool marks of any significance, and those not extending more than an inch or so on the sides. The thickness of the lead at the corner will be neither more nor less than on the unworked parts. Some plumbers would now be able to cut off a small portion of the superfluous lead, but a young plumber will probably have driven too much into the corner and will be wondering where he is going to get sufficient to complete it. The corner must not be worked to a sharp arris, but should be slightly rounding, and left so until the finishing is done.

The corner can now be finished, when it will have the appearance shown by Fig. 496. The small lug at K can be cut off, and by holding a hard boxwood dresser tightly and firmly against the inside, and planishing the outside with a

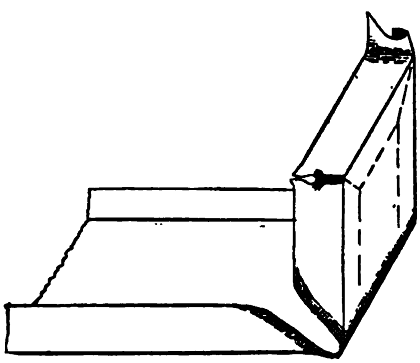

FIG. 495.

small hand-dresser, having a smooth and slightly rounded face, the whole of the tool marks can be worked out in a very short space of time. The angle should be left quite straight, and of the same roundness as those in the sides and which meet at the point.

Just a word on using "touch" on the bossing stick. This should never be done as it makes the tool slip off the lead, so that it cannot be dragged. The work and tool are also made dirty. This getting onto the hands, and eventually onto the dress, does not add to the plumber's personal appearance. My assistants, or mates, were always taught to wash all boxwood tools and keep them clean and in good condition. When working on roofs during wet weather they were sometimes rubbed over, after washing, with a rag dipped in linseed oil to prevent them becoming soaked with water and so soft as to be almost useless.

Referring again to Fig. 492, the corner at L should be cut out as shown by the dotted lines. This corner has to be bossed up to the height of the wood roll and hollowed on the outside to

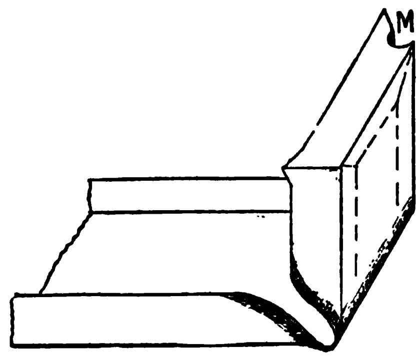

FIG. 496.

fit. When finished it will have the appearance shown at M, Fig. 496 and 497. After the two corners have been bossed up the bay should be laid down flat, the sides, which were opened out when the end was stood up for the plumber to do his bossing, pulled up, and the angles set in. The sides to be made straight, the bay laid in its position between the roll and side wall, and a piece of board laid on the stiffening creasings. By jumping on the board these ridges, as they appear on the surface, will be pushed down, and at the same time the sides will be forced against the walls and roll respectively, when all

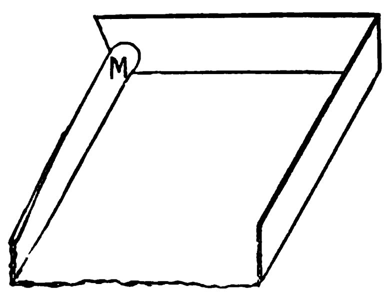

FIG 497.

that remains to be done is to straighten the angles and sides, dress them against the side and end walls and the undercloak so as to fit close round the wood roll, nail the edge and work the roll ends.

A great many country plumbers would be

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astonished if they saw what some of those who work in London, Newcastle, Glasgow, and some other large towns can execute in lead. If they were told that a long length of pipe could be bossed out of sheet lead they would wonder how it could be done; but if they were told that not only a length of soil-pipe, but several branches out of it could be so made, they would feel inclined to doubt the statement. We will now deal with such a problem and explain the proceedings. The example is taken from an actual piece of workmanship that was exhibited by a journeyman plumber a few years ago at the London Agricultural Hall.

A sketch of the finished piece of work is shown by Fig. 498. Large numbers of plumbers saw it and admired it very much. Some were doubtful as to the genuineness of the statement that it was made out of a strip of lead about 34 ft. long by 18 in. wide, without any soldering, burning, or other means of joining. The rolls at the sides show the lead that was to spare, and also that the piece could have been continued to a greater height and have had more branches if the plumber had cared to go on working. The plumber did not explain to his admiring audience how he managed, or describe the proceedings or methods he adopted. Speaking from memory, the piece of work stood about 5 ft. high, the end, A, was about 7 in. in diameter, the base, B, 9 in., and the four branches, C, D, E and F, about 5 in. across. There are several ways for beginning such a piece of work, but the simplest would be to measure the length of lead required, the dimension being taken all round the outside, as shown by the dotted lines. The rolls at the sides are unnecessary and only left on to show that the work could have been continued. The only limit to this being the length of the sheet out of which the lead has to be cut. The width of the lead to be guided by the diameter of the intended piece of work. Roll up the ends of the lead and fold it as shown by Fig. 499, the piece being stood on the floor ready for beginning to do the bossing. Hold the head of a good sized box mallet inside the part G, and with the side of a small bossing mallet, or a bossing stick, begin working the edge of the lead inwards, as shown by the upper arrows. After a few inches have been worked down, it will be found that a hard piece has gathered into a buckle at H. Part of this should be cut off and then the bossing continued to J, when it may be found necessary to cut off a further piece similar to the first. Again proceed as before until the desired length has been obtained. Fig. 500 shows the bossing completed at K, and the lead again folded ready for another branch. Treat this as the other one, then again fold the lead as shown by Fig. 501, and boss this up in the same manner. After the other branches have been worked-up, the whole to be shaped as shown by Fig. 498, and the side of the main trunk to be worked down in a manner similar to the branches. The whole of the working to be done whilst the lead is laying on the floor. After one side has been completed the whole to be turned over, the worked side being on the floor and the unworked side uppermost. To prevent the piece of work getting out of shape it may be necessary to place blocks under the ends of the branches to support them. Begin at the top, which is represented by A, Fig. 498, and work it down to the first branch. Boss the side of this branch down to the trunk which should then be worked to the next branch, and so on until the whole is completed. If the base is flanged, as shown below, B Fig. 498, care must be taken not to thin the lead in the angle. To prevent this, some of the lead should be dragged in from the margin. After proceeding so far, cut holes in the ends shown by A, C, D, E and F, work them out to the sizes of the branch pipes. To prevent the lead getting thin round the holes, the edges should be driven inwards to thicken them as the

FIG. 498.

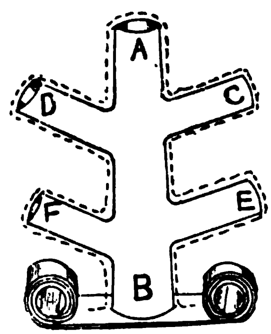
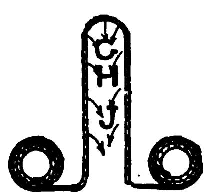


FIG. 499.



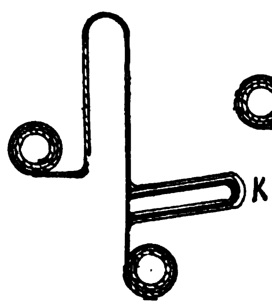


FIG. 500.

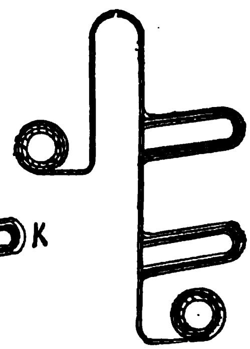


FIG. 501.

holes are increased in size. Another way would be to saw off the closed ends of the branches, but this would shorten them a little. A good, heavy hand dummy, with a straight head, can now be held inside the various parts and the outside planished with a hard boxwood dresser with a slightly rounded face. When carefully worked the whole of the piece would have the lead of an equal thickness throughout and the tool marks entirely obliterated. Some plumbers

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will do the latter by means of rasping and shaving, but this is a very unsatisfactory proceeding. A student plumber at the Polytechnic bossed up a 4 in. cross piece out of a piece of 5 lb. lead, as shown by Fig. 502. Although it was his first attempt at such work, he succeeded in making it in a very creditable manner. This was made out of a round piece of lead. He first made it in the form of a balloon, or pear-shaped, this was then bashed on the bench to flatten opposite sides which made it the shape as shown by the dotted lines in the figure. The internal angles were then worked into the proper shape, the three closed ends worked out, a box-wood mandril pushed through and all tool marks planished out with a dresser.

Another example of skilful lead bossing is when a 4 in. pipe has to pass through a lead roof and it is not desired to solder the two together. In this case the stand up lead has to be dragged from the flat part laying on the roof. Such a

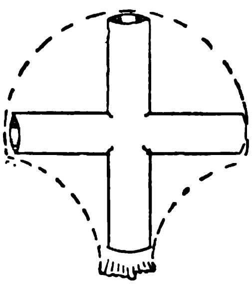

FIG. 502.

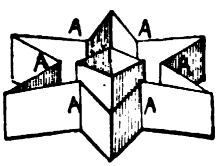

FIG. 503.

piece was described in an earlier lecture and illustrated by Figs. 306 and 307.

A still more difficult piece of work, almost similar to the last, is shown by Fig. 503. The centre should be bossed up first as for a round pipe and then made square afterwards. The sketch is taken from an actual piece of workmanship, the centre pipe and sides being 6 in. high, the piece of lead being 2 ft. 9 in. in diameter before commencing, and weighing 6 lbs. per superficial foot. When making the centre part it is a good plan to boss up the pipe an inch or so higher than the 6 in., then make the upper portion square, after which lay a soft piece of wood on the top and drive it downwards with a heavy mallet, partly set in the bottom angles and then drive down again as before. By doing this two or three times and dragging some of the lead from the bottom or flat part, into the angles, the lead will not be reduced in substance in any part, although some places will be slightly thickened. After doing this a few times, the piece of work will look like that shown by Fig. 306, excepting that the centre pipe will be square on plan.

Before describing the outside portion of the work shown in the figure we had better deal with a similar, but more elementary problem. When laying lead on roofs the stand-up parts of the lead have frequently to be bossed to fit round projections such as chimney stacks, skylights, dormers, trap-doors, &c. The lead standing up in an internal angle is called a "corner," but when against an external angle it is called a "break." The angles shown at A A, Fig. 503, are also called breaks. With a corner there is an excess of lead, as has been explained, but with a break it is the opposite. Where a corner and a break come close together part of the surplus lead in the one can be worked into the other to make up the deficiency, but not to so great an extent as sometimes considered. Where the break is at some considerable distance from the corner then the whole of the lead to form the break has to be worked in from some other part. We will now deal with such a case. Let Fig. 504 represent a piece of lead, the shaded part laying on a flat roof, and the thick line representing an external angle of a wall, against which the lead has to stand up to to a height of 6 in. The thin line is the edge of the lead for turning up. If the piece of lead, B, was cut off on the thin line there would not be sufficient left for bossing purposes. If the student takes a piece of stiff paper, marks it as shown in the figure, cuts off the piece B, and then on the dotted line C he can turn up the two sides, when he will find that a piece of lead 6 in. × 6 in. is wanting, as shown at D, Fig. 505. If cut on the dotted line E, Fig. 503, and then turned up, a piece of lead equal to 6 in. × 6 in. would still be wanting. This piece should be taken from B, in other words, should be left on instead of being cut off. We know the size necessary to fill up the gap shown at D, Fig. 505, and this size should be marked on the corner, B, Fig. 504, as shown by thick dotted lines at F. If cut out exactly as shown the lead would tear in the corners G G, when being worked, and, to prevent this, gusset pieces should be left on as shown in the figure. This will give an excess of lead over what is wanted, but it is best, as the student generally gets the edge of the lead, when working it, so thin as to break it, and has to cut off this thin selvage to prevent the tear getting larger. As he gets more skilful and experienced this does not occur. With a good workman this excess of lead is worked in so that the break is slightly thicker than the other parts of the lead. As a good specimen of workmanship this extra thickness would be a blot on it; but it may be urged that in practice a break is fixed against a sharp corner of stone, or against brickwork, and the lead would be less liable to be cut or otherwise injured if made a little thicker in the angle.

When bossing up a break the first thing after cutting out the lead to the proper shape, is to set in the bottom angles. This should be done very lightly, the lead being laid hollow or the side held up by the assistant so that the lead does not lay solid on the bench, floor, or roof, as the case may be, and the plumber can

just crease the angles without bruising or cutting into the lead. Neither should the angles be set in very sharp. When working the break the lead is driven inwards in such a way that the bottom angles are sometimes buckled, and on working these out the angles will crack and eventually open. After the bottom angles have been creased sufficiently to show the intended shape of the piece of work some plumbers will pull up the sides, or stand-up parts, and thus make a bad beginning in that the piece of lead is at once put out of shape. The plumber should stand the piece of lead on its side or end, as may be most convenient, and begin working the break. The tongue piece at F, Fig. 504, should be folded inwards, as shown at H, Fig. 506, and the outside of the fold worked in the direction shown by the arrows. The

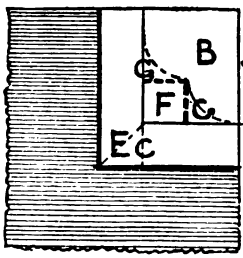

FIG. 504.

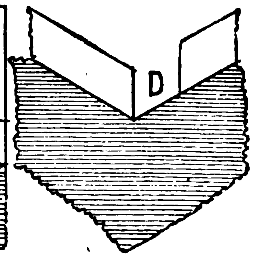

FIG. 505.

tongue should not be held firmly down or the lead would become thickened, but should be allowed to slowly open out, which it will do when working the lead. The tongue should be again folded and the working repeated, but the lead now to be driven more towards the base of the intended angle. The tongue part will now become so that it cannot be folded, and must be worked down with a smooth bossing stick. The most important point to bear in mind is that the edge of the lead tongue part, as we have termed it, shall always be in advance of the other parts. If this is not done the lead will become reduced in substance between the outer edge and bottom angle. When once the lead has been reduced in thickness it is very difficult to thicken it up again, and any thin parts are always liable to break, even when the plumber is working two or three inches away from them. This will apply with more force when it is explained that a thin place often has a very thick part adjoining, and working on the thick places has more effect on the edges than on the centre. For these reasons a bossing stick is preferable to a mallet, the lead being more uniformly worked by the former. As the centre portion of the break is travelling towards its position the sides, J J, should be folded with the hands. If these sides are knocked in with tools the end of the stand-up will become stretched, so that on completion it will be found necessary to re-set in the bottom angle, and in numbers of cases the lead is torn when doing this. As a matter of fact, the lead sides beyond the dotted lines should not be touched with the tools when working up the break, and only require to be dressed straight on completion of the work. On this, it may be added, that if the plumber attempts to drag some of the side lead into the break he is in constant trouble, and has to frequently lay the piece of lead down to get it into shape again. In such cases the corners, K K, are made short, as shown by dotted lines, and the bottom angles have to be again set in on quite different lines to those originally made. By being in too much of a hurry, sometimes when trying to be

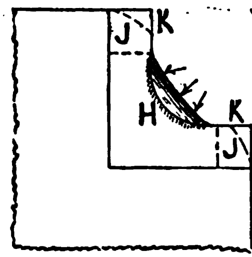

FIG. 506.

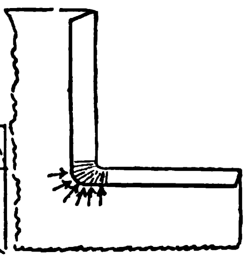

FIG. 507.

quick, the piece of lead has become so much out of shape that some parts have to be stretched to get it back again, and the lead thus reduced in substance.

If the piece of work has been commenced as above described, and a light bossing stick used, the student plumber will have little difficulty in making a very respectable looking break with very few tool marks; but if he attempts to use the mallet, or even a heavy bossing stick, and goes in for "slogging," he will find that twice the time has to be spent on what he is doing than when done in the proper way. It only remains to be said that the break must be kept hollow, as shown by Fig. 507, until the completion of the working, and not made into a square angle until being finished off. If the break should be so worked as to stand up ½ in. or 1 in. higher than necessary, the surplus lead can be worked in by driving the top edge inwards, as shown by the arrows, and thus use it to thicken the angle instead of cutting it off. There are a great many more details in this problem that could be mentioned, but the great difficulty in writing is to make them clear. The student plumber would learn more in a few hours practice than he could in reading a book full of description. If he intelligently carries out what has been written above other portions of the problem will fill in as he proceeds with his work. His first attempts should be slowly and carefully made, the effect of each stroke of his tool watched, and the movement of the lead noted. In the class-room it has frequently been noticed that by standing at a student's elbow and directing his actions a really good piece of work has been executed at the first attempt, but ask him afterwards to

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make a similar piece, and leave him to his own resources, a woeful failure has resulted. Hence the above remarks about practice being all important. We will now deal with a break and corner combined.

Fig. 508 represents such a piece of work when completed. When the corner and break are nearly close together some of the surplus material of the former can be worked into the latter, but it is very difficult indeed to get the whole of the surplus of the corner worked into the break. To set out the lead for such a piece of work, as shown by Fig. 508, the above must be borne in

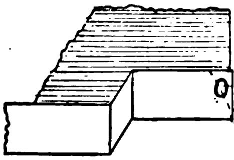

FIG. 508.

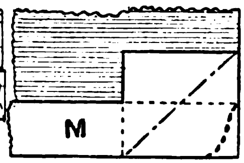

FIG. 509.

mind, otherwise, too much will be cut out of the break. It must also be remembered that it is easier to manipulate the lead from the free, or outside edge, than from any other part of any piece of work of this kind. Fig. 509 shows the lead set out ready for cutting and working. The thick lines are the sides, or stand-up parts; the thin dotted lines show the setting out, and the thick dotted line the part to be cut off. The lead should be first creased with mallet and dresser on the thick line and then stiffening creases made on the other side of the lead. The side M should then be folded up, the folding being continued on the thin dotted line to the end. The piece of lead will then be as shown by Fig. 510. The straight dotted lines in the latter figure represent the angles that will be on completing the work. After standing the piece of lead on its side, end, or any other position for easy working; the plumber will

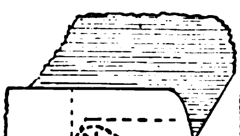

FIG. 510.

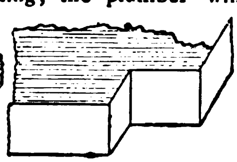

FIG. 511.

begin by bossing the part shown by curved dotted line at N. This will stiffen the corner and help to prevent it being dragged out of shape in the manner described and illustrated at A, Fig. 490. The plumber will then gradually work the lead into the internal angle—that is the break, by easy stages, following the instructions given for Figs. 506 and 507. When doing this the corner will be found to open out a little, when it will be found necessary to boss it up a little higher, and so on from time to time until the work is completed, as shown by Fig. 508.

Instead of folding the sides of the piece of lead ready for bossing as above explained, a great many men will do so on the chain line, shown on Fig. 509. The break can be worked up a little quicker this way, but the job will be a poor one in that the stand-up part will be short, as shown by dotted lines at O, Fig. 508, and more lead would be cut off the bossed angle. By working as described for Fig. 510 this is avoided.

When a break and double corner, as shown by Fig. 511, have to be bossed up the task is not at all difficult. After setting out the piece of lead, creasing the angles, and putting in stiffeners, the corner should be folded up, as shown by the chain line on Fig. 509 (excepting that the latter figure does not show the other side to form the second corner), and the two corners bossed up about 1½ in. to 2 in., as shown at N, Fig. 510. Sometimes this bossing is carried too far up, with the result that the lead which has to be worked into the break is left projecting like the outside of an inflated bag. On attempting to work this bag inwards the lead is knocked into a lot of hard lumps and buckles, the bottom creasings to form the angles are pushed out of shape and the task is rendered doubly difficult to execute. Although the corners should be first started, only sufficient should be bossed up to render them so rigid that they cannot be dragged out of shape, as predescribed, when working on the other parts. The corners should not be completed until the break has been finished.

A piece of bossing often met with is shown by Fig. 512. This is much more difficult to do than any of the preceding examples, especially when the breaks are some distance in and not very far apart. The setting out of this is shown by Fig. 513. The whole of the piece of lead should be used, although some plumbers will cut out a small piece, as shown by the curved dotted lines. The lead should be set in as described for the other examples, and then folded on the lines P, P, P. The plumber to commence working from the centre, driving the lead downwards and inwards at the same time. After the centre part has been worked back to its intended position the corners to be started as described for Figs. 510 and 511, and then the breaks worked. If care is not taken when bossing the piece of lead it will be found that the angle formed by the line R, Fig. 512 and 513, will become very much out of shape, and to get it back to its position the lead has to be reduced in substance. This is sometimes carried to such an extent that the lead is torn.

The remark has been made that where a break and corner come close together part of the surplus of the latter can be worked into the former, "but not to so great an extent as sometimes considered." No two plumbers work alike, each one has a peculiar way of his own. An unskilled plumber will have the thinnest parts of bossed breaks at the corners, S, S, Fig. 512 and 513, that is if he succeeds in work-

ing them without tearing the lead. With a skilled plumber this is not so, and the lead is generally of an uniform thickness throughout. But with plumbers of all kinds there is generally a weak place in a bossed lead break, and that place is mostly to be found where shown by the star, Fig. 512. This position being not far from

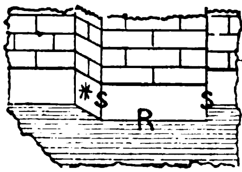

FIG. 512.

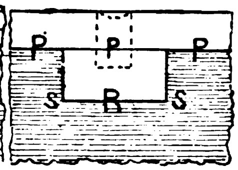

FIG. 513.

the angle, shows that, in spite of endeavours made, the surplus has not been worked from the corner to the extent sometimes considered. The top edge of the stand-up lead may be kept an equal thickness but the part mentioned is frequently found to be thin. At exhibitions of plumbers' works, the judges generally test that part of a break with their thumbs and find it yield to a very gentle pressure when not properly made.

In the examples, of bossing breaks, that we have dealt with we have assumed that in each case the piece of lead has been large enough for the purpose, and there has been a free edge on which the plumber could work, so as to drive in sufficient material for his purpose, without it being necessary to reduce the substance of the other parts. But there are cases where such is not the fact and one portion of the lead has to be robbed of its thickness to provide sufficient for another purpose. Such an example is shown by Fig. 514. This represents the piece of lead bossed up and laid on the floor of a bell turret, which is supported on posts. The lead having to be worked up to fit round the posts, which are 6 in. by 6 in. thick, and also round the curb of a trap-door. In each case the lead was worked up as if to fit posts round in section and a much larger size, as shown at T, T. When placed in its position the lead was worked back to the posts, but was dragged from the flat parts to get sufficient to stand up 6 in. high. The other portions of the figure show

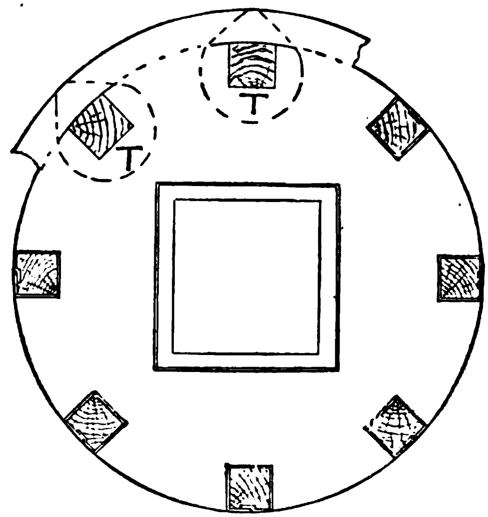

FIG. 514.

the work completed. A great deal of skill was necessary to do this without breaking the lead, but the whole work was satisfactorily done and all parts left as nearly as possible of an uniform thickness, although much thinner than before being worked. From what has been said it will not be necessary to refer to the outer portion of the piece of lead shown by Fig. 503.

FIXING W.C.'S.

WE can now return to the subject of W.C.'s and deal with the various details that have to be considered in connection with their arrangement. We may premise further statements by saying that for years past advanced sanitarians have known of certain evils in connection with our subject, and have tried to remedy them. But they have only been able to carry out their improvements on a very small scale. The various Acts of Parliament referring to the public health have done a great deal in certain directions to improve the sanitary condition of the people. But they have in many cases either been only partly acted upon or remained dead and inoperative. Neither were they explicit enough in their statements. In numbers of cases they have been interpreted according to the wishes of the reader rather than to the spirit of the intentions of the legislature. The outcome of all this has been the passing, for London, in 1891, of a Public Health Act. Section 39 of this Act states: "The County Council shall make bye-laws with respect to water-closets, earth-closets, privies, ashpits, cesspools, and receptacles for dung, and the proper

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accessories thereof in connection with buildings, whether constructed before or after the passing of this Act." Acting on these powers the London County Council in June of this year, 1893, issued their bye-laws. These bye-laws have evidently been drawn up with great care and speak well for the Council's advisers in the matter and their efforts to thoroughly grasp the various subjects, including water-closets. Without committing oneself to the statement that the various details covered by the Council's bye-laws are perfect, we may take them as being nearly so. And although they are drawn up especially for the County of London, they are equally applicable to other towns and places; to engineers, either in public or private practice. In this statement it is not forgotten that various towns may have excellent bye-laws of their own, drawn up to suit the requirements of the localities. As the regulations are generally applicable we will now deal with those portions which refer to the subject of our heading.

With regard to the position of water-closets, Clause 1 states: "Every person who shall hereafter construct a water-closet . . . shall construct such water-closet . . . in such a position that . . . one of its sides at least shall be an external wall . . . which external wall . . . shall abut immediately upon the street, or upon a yard or garden or open space of not less than one hundred square feet of superficial area, measured horizontally at a point below the level of the floor of such closet. He shall not construct any such water-closet so that it is approached directly from any room used for the purpose of human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop, or workplace. Nor shall he construct any earth-closet so that it can be entered otherwise than from the external air." These are most excellent arrangements and will get rid of a very common evil. We sometimes find W.C.'s fitted up in bedrooms with only a thin wooden enclosure to screen them from view. In some mansions the W.C.'s are recessed in bedroom walls, with doors to look like cupboards. In numbers of cases we find a bath-room containing a W.C., the door of the room opening into a bedroom. There are houses, occupied by wealthy people, with a W.C. in the scullery, the only light or ventilation to the closet being obtained from the scullery. We need not go through a long list of unsuitable positions for W.C.'s, but simply add that there are numbers of work-rooms with a W.C. enclosed in a corner, and it is not at all uncommon to find such fittings in bakehouses.

Wherever a water-closet "abuts on a room intended for human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop, or workplace, it shall be enclosed by a solid wall or partition of brick or other materials extending the entire height from floor to ceiling." The evils of hollow partitions for separating water-closets from rooms have been referred to before, and an example was shown in Fig. 451. If the partitions must be so that air cannot pass through, it follows that ceilings should also be in a similar condition. This is very important when water-closets are situated beneath bed or similar rooms. We often find a cistern over a water-closet and no ceiling whatever over it. There are also examples, where pipes are enclosed in wooden casings, through which smells in water-closets are carried by air currents to other places. The spirit of the above bye-law intends that there shall not be any openings whatever through which air from a water-closet can pass into any part of a house where it would be obnoxious or injurious to the people.

Referring to outside closets, the bye-law states: "He shall provide any such water-closet that is approached from the external air with a floor of hard, smooth, impervious material, having a fall to the door . . . of ½ in. to the 10 ft." We frequently find these outside places with wooden floors in various stages of decay, and it is very difficult to prevent this decay owing to the floors being laid close to

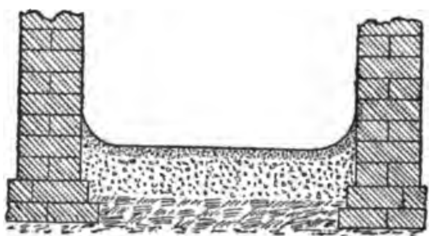

FIG. 515.

the earth and having no ventilated air-space beneath them. Good Portland cement concrete, trowelled to a smooth surface, makes very good floors. A further advantage is to make the angles hollow next to the walls, as shown by Fig. 515. If the closet-basin is one of the kind, that was referred to in a previous lecture, which can be fixed clear of the floor, the latter can be washed clean without any difficulty whatever with water and a broom.

Decency is provided for by the paragraph which states that "He shall provide such water-closet with proper doors and fastenings."

The last paragraph of this first bye-law states: "Provided always that this bye-law shall not apply to any water-closet constructed below the surface of the ground and approached directly from an area or other open space available for purposes of ventilation, measuring at least 40 superficial feet in extent, and having a distance across of not less than 5 ft., and not covered in otherwise than by a grating or railing."

The second bye-law states that "Every person who shall construct a water-closet in con-

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nection with a building . . . shall construct in one of the walls of such water-closet . . . a window of such dimensions that an area of not less than two square feet, which may be the whole or part of such window, shall open directly into the external air. He shall in addition to such window cause such water-closet . . . to be provided with adequate means of constant ventilation by at least one air brick built in an external wall of such water-closet . . . or by an air shaft, or some other effectual method or appliance." When lecturing on Fig. 451 the evils of a small window were mentioned, and here it need only be stated that an ill-lighted closet is generally found to be very dirty and the W.C. seat fouled by improper usage. Ventilation of the apartment is a very important problem. In the first place, the ventilation should go on independently of the rest of the house. Provisions for the circulation of air in the closet can be made, but success depends upon the people who use the place closing the door behind them. So long as the door is open air will be found to pass inwards through the open window or ventilating gratings thus blowing any smells hovering in the closet into the house. When the door is closed the air will circulate in the closet, provided there are two openings into the external air, passing inwards through one opening and outwards at the other. These openings should be placed as far distant as possible, and at different levels. It is never safe to say which shall be the inlet and which the outlet, unless mechanical ventilation apparatus is fixed, as the direction of the air currents will frequently be found to change. But of this we need not take any notice so long as the air in the apartment is continually being changed. To prevent careless people leaving the door ajar it is advisable to fix a spring for closing it. There are excellent springs to be bought by which the doors are closed slowly but firmly. Ordinary back springs are very objectionable. Children's fingers and ladies' dresses frequently come to grief by their use. Referring again to the ventilating openings through the external wall, it may be added that they should always be placed where a cold current of air passing inwards would not be objectionable. Where there is little or no choice with regard to position of the openings, so-called Tobin tubes, some of the patent ventilators, or carefully adjusted deflecting plates, can be used for directing the air currents from playing on to a person in the closet. Whatever is used should be made easily removable. Dust will often accumulate inside and should be frequently cleared away.

Bye-law three states "That every person who shall construct a water-closet in connection with a building shall furnish such water-closet with a cistern of adequate capacity for the purpose of flushing, which shall be separate and distinct from any cistern used for drinking purposes, and shall be so constructed, fitted, and placed as to admit of the supply of water for use in such water-closet, so that there shall not be any direct connection between any service pipe upon the premises and any part of the apparatus of such water-closet other than such flushing cistern."

Unfortunately for us Londoners we cannot use "a cistern of adequate capacity for the purpose of flushing" owing to most of the Water Companies' regulations limiting the quantity to two gallons. All we can do is to make use of the allowed quantity to the best advantage, but where there is no limit a better flush should be arranged. We should also select an apparatus that ensures the whole of the flush being utilised. These details were dealt with in earlier lectures, see the text accompanying Figs. 469 to 477. In several previous lectures references were made to the pollution of drinking water by being in connection with W.C. apparatus. A very common way is shown by Fig. 451, where not only the flushing pipe to the basin, but also the waste pipe connection with the trap, are the means by which bad air can be conveyed into the cistern. Other examples are sometimes met with where the service pipe from a cistern has branches connected with W.C.'s flushed by underseat valves, similar to Fig. 469, also to taps over sinks for supplying drinking water. A tap being opened on a lower floor will sometimes prevent water passing into a W.C. at a higher level when the handle is raised. In some cases when the two valves are opened at the same time air will be sucked into the pipe through the upper valve, and if this is connected to a W.C. the water in the pipe becomes polluted. In this case, if the closet trap happened to be choked and the basin full of slops or other offensive matter, this would be syphoned into the service pipe. There are numbers of ways by which drinking water can be contaminated by connections with W.C.'s, so that it becomes imperative to carry out the bye-law in its entirety. The only exception allowed is when the cistern "is used solely for flushing water-closets or urinals."

Another instruction in this (No. 3) bye-law is that the pipes and unions from flushing cisterns "shall not in any part have an internal diameter of less than one inch and a quarter." The value of this regulation will be understood when it is explained that sometimes very light lead pipe is used, and in the hands of an unskilled plumber the necessary bends are so crippled and contracted in the throats that the waterway is reduced to the detriment of the flush to the W.C. With great numbers of the cheaper kinds of flushing cisterns the union connections to the bottom, for joining the flushing pipes, are much smaller than their nominal size. This again interferes with the value of the water flush.

Water-closets without water are an abomination, but strange to say there are places in London where such is the case. The bye-law states "He shall furnish such water-closet with a

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suitable apparatus for the effectual application of water . . . for the effectual flushing and cleansing . . ." This regulation will compel householders to have proper flushing apparatus to each W.C. The writer has found W.C.'s which were never flushed excepting when someone threw down a pailful of water. In other cases he has seen W.C.'s that were flushed by means of waste pipes from sinks. In one row of houses some years ago the writer found the only flushes to the W.C.'s were the overflow pipes from the cisterns which held the drinking water. To flush the W.C. the person had to reach over the top of the cistern to pull out the standing waste pipe and then replace it. Such abominations it is hoped will now be swept away.

With regard to the W.C. basins, or apparatus, they must be made of "non-absorbent material, and of such shape . . . as to receive and contain a sufficient quantity of water, and to allow all filth . . . to fall free of the sides thereof and directly into the water . . . He shall not construct or fix under such pan, basin, or receptacle, any 'container' or other similar fitting." This section will get rid of the long hopper basin, pan closet, and such like fittings that advanced sanitarians have condemned for several years past. The same bye law insists upon "an efficient syphon trap so constructed that it shall at all times maintain a sufficient water seal between the pan, basin, or other receptacle and any drain or soil pipe in connection therewith. He shall not construct or fix in or in connection with the water-closet apparatus any D trap or other similar trap." In previous lectures the writer dwelt for some considerable time on traps of all kinds, those mentioned in the bye-law included. If the reader refers back to the text accompanying the illustrations 220 to 283 inclusive, he will find the "D trap" and "other similar traps" described, also others of a better kind, and it is not necessary here to repeat what has already been said on the subject. Plumbers and sanitary engineers will now find that their hands are strengthened when dealing with crotchetty or obstinate clients. There are several even in this advanced age who will insist upon retaining some of the objectionable fittings that have been condemned in this bye-law. Believers in so-called "trapless closets" will doubtless find their confidence in those fittings shaken when they find that those responsible for the public health have condemned their use. Having so far explained the leading points in connection with our heading, we will now take up the next paragraph which deals with what is generally known as "trap ventilation."

"If he shall construct any water-closet or shall fix or fit any trap to any existing water-closet or in connection with a soil-pipe, which is itself in connection with any other water-closet, he shall cause the trap of every such water-closet to be ventilated into the open air at a point as high as the top of the soil-pipe, or into the soil-pipe at a point above the highest water-closet connected with such soil-pipe, and so that such ventilating pipe shall have in all parts an internal diameter of not less than 2 in., and shall be connected with the arm of the soil-pipe at a point not less than 3 in. and not more than 12 in. from the highest part of the trap and on that side of the water-seal which is nearest to the soil-pipe." This subject was dealt with some time ago, and the illustrations shown by Figs. 335, 336, and 338 A, clearly explain the intentions of this section of the bye-

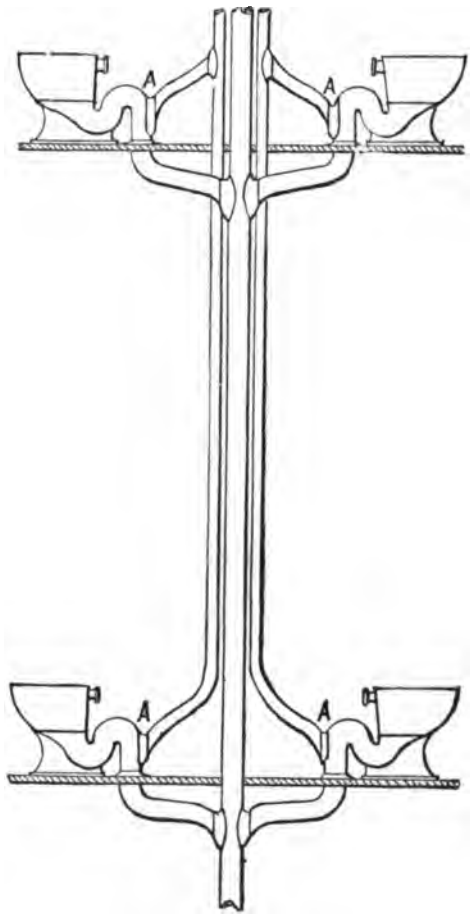

FIG. 516.

law. The student should carefully read the text which accompanies the above figures so that he may the more clearly understand the reasons why the foregoing regulations are considered necessary.

In the illustrations that have been referred to the traps are fixed to show certain principles, but in practice it will be found that there are

numbers of cases where the work is not of the character illustrated. Take as an example a tier of W.C.'s with so-called S-traps instead of the P.'s shown in the above figures. These would be necessary in cases where the branch soil-pipes must be fixed under, although the traps are above, the floors. Under these conditions the ventilating pipes would be connected as shown at A A, Fig. 516. The trap ventilation from the W.C. can be carried up separately or connected to the pipe from the other W.C. traps as most convenient. If several W.C.'s are on a single soil-pipe, as shown in the figure, it is then an advantage to have two main trap-vent-pipes, or if one pipe is used it then becomes necessary to increase the size for reasons that have been given and need not be repeated.

Fig. 516 shows lead traps to the W.C. basins, but there are numbers of fittings which have either earthenware traps attached or the basins and traps are separate, but both being made of the same material. This revives a detail mentioned in an earlier lecture, namely, the position of the vent connection to earthenware traps. Certain objections were taken to the common shapes, as shown at A, B, and C, Fig. 463, and which are not in accordance with the bye-law. D, in the same figure, and the trap and basin shown by Fig. 454, are both nearly what is required, but it is doubtful if the County Council's officers would consider the vent-arm as being "not less than 3 in. from the highest part of the trap." As a matter of fact, the writer only knows of one W.C. trap with the ventilation arm fixed as shown by the last illustration referred to. Unless makers take this hint it is very probable they will find a lot of their goods rendered unsaleable in London owing to this small detail being overlooked. It will also be necessary to have the vent-arm of such a kind that a reliable joint can be made between it and the ventilation pipe.

With regard to soil-pipes, the fourth bye-law states : "Any person who shall provide a soil-pipe in connection with a building to be hereafter erected, shall cause such soil-pipe to be situated outside such building; and any person who shall provide or construct or refit a soil-pipe in connection with any existing building, shall, whenever practicable, cause such soil-pipe to be situated outside such building, and in all cases where such soil-pipe shall be situated within any building shall construct such soil-pipe in drawn lead, or of heavy cast-iron, jointed with molten lead and properly caulked." In earlier lectures the writer dealt with soil-pipes and the advantages and disadvantages of fixing them both internally and externally. If the reader refers to those earlier lectures he will find the arguments used and thus save repetition here. The bye-law insists upon the outside position, and we are bound by this regulation. The caulked joints to iron pipes were described in the lecture on iron drains, and illustrated by Fig. 357; but for soil-pipes the joints would be vertical instead of horizontal.

Dealing with the strength and sizes of these pipes the bye law states, "He shall construct such soil pipe so that its weight in proportion to its length and internal diameter shall be as follows":—

Diameter.	LEAD. Weight per 10 ft. length. Not less than—	IRON. Weight per 6 ft. length Not less than—
3½ in.	65 lbs.	48 lbs.
4 "	74 "	54 "
5 "	92 "	69 "
6 "	110 "	84 "

By working out the given weights for the lead soil pipe it will be found that the thickness of the sides is 0·118 in., this being generally known as 7lb. lead, that is, equal to sheet lead weighing 7 lbs. per superficial foot, and not as weighing that number of pounds per foot in length of pipe. The table gives the lowest weight that is allowed, but there is no limit to heavier pipes being fixed where desired It may be added that very few first class plumbers fix pipe so light as given in the table, 8 lbs., 9 lbs., and 10 lbs. per foot superficial being the more common weight for soil pipes. The weights given for iron soil pipes are very light, and only suitable for the very lowest class of work. The thickness is not 3-16ths of an inch, and any one who has had any experience in fixing cast-iron pipes knows that about half that thickness is all that can be depended upon. Eighty to ninety per cent. of iron soil pipes are found to be very thin on one side, and correspondingly thick on the other. The pipes appear to be all right as seen at the ends, but a pair of long calipers must be used to discover the weakness referred to. Neither will pipes of this weight resist the caulking of the lead joints unless very carefully done. In this case, too, the bye-law will allow heavier pipes being used, and this should be where the work is to be done in a thorough manner.

The bye-law further states, "Every person who shall provide a soil pipe outside or inside a building shall cause such soil pipe to have an internal diameter of not less than 3½ in., and to be continued upwards without diminution of its diameter, and (except where unavoidable) without any bend or angle being formed in such soil pipe, to such a height and in such a position as to afford by means of the open end of such soil pipe a safe outlet for foul air, and so that such open end shall in all cases be above the highest part of the roof of the building to which the soil pipe is attached, and where practicable be not less than 3 ft. above any window within 20 ft. measured in a straight line from the open end of such soil pipe."

The first portion of this clause is also permissive. The sizes of the soil pipes can be any

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size between 3½ in. and 6 in. in internal diameter, but not less than the first named. It is not necessary to repeat the arguments that were used some time ago in reference to sizes of soil pipes, but simply say here that only in very extreme cases is it necessary to use a larger pipe than 4 in. in diameter. Above that size a large amount of incrustation will form inside. So we may accept as an explanation of the regulation that the smaller soil pipe should be used in ordinary dwelling houses, and the larger pipes only in exceptional cases. The latter portion of the above regulation will lead to some controversy in the near future if carried out with strictness. The interpretation is very difficult, and those anxious to carry it out will experience some difficulty. If all houses had flat roofs there would be no trouble in the matter, but there are large numbers of slated and tiled roofs where the pipes must have bends in them to get to the desired positions. There are cases, too, where some portions of the roof are higher than others, and the rule may require a long length of pipe with several bends in it to get to "the highest part of the roof of the building to which the soil pipe is attached." The clause states, in parenthesis, "except where unavoidable," but opinions are bound to differ on this point. To further explain this, a case occurred where an architect designed a building and had the soil vent pipe fixed as shown by Fig. 517, the pipe being hid behind the coping of the gable, as shown by dotted lines at A. The inspector insisted upon this being taken down and carried up straight, as shown by firm lines at B, and this in spite of the architect's protest as to the ugly appearance it presented.

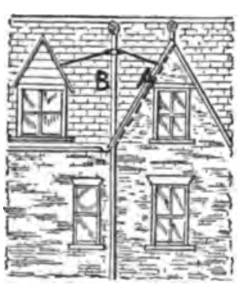

FIG. 517.

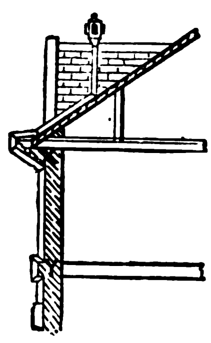
FIG. 518.

Although this was not done under the County Council's bye-laws, there is reason for thinking that something similar will occur under the new rules. All that we, as plumbers, can do is to consult the proper officers in such cases, and so avoid having to alter any work that we may have executed. Architects, too, will have to give more thought to the positions of water closets if they do not want their houses to be disfigured with unsightly pipes, propped up with long stay rods or other fixings, showing above the eaves of their houses. Bends in ventilation pipes are very objectionable, owing to the friction they cause, and thus impede the velocity of the air passing through. An example of unnecessary bends is shown by Fig. 518, which was sketched from a house only a few doors from the example shown by Fig. 517. The pipe was of zinc, 3 in. in diameter, and had nine mitred elbows, some at right angles, as shown by the sketch. By cutting away the string course at Y and the cornice at X, seven of these elbows could have been avoided. And then, again, elbows are always objectionable; easy bends, made as shown by Fig. 285, should be made instead.

Fig. 332 illustrates a wire grating for fixing on the top ends of soil ventilator pipes, and which meets the regulation, "He shall furnish the open end of such soil pipe with a wire-guard covering, the openings in the meshes of which shall be equal to not less than the area of the open end of the soil pipe." From this it is evident that cowls of any kind are not allowed to be used on soil pipes, nor any ends made as shown by Figs. 333 and 334. The objections to such arrangements will be found in the text accompanying the latter figures.

When iron soil pipes are fixed the bye-law stipulates, "In all such cases where he shall

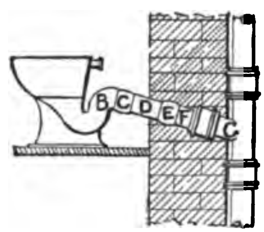

FIG. 519.

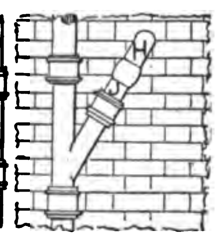
FIG. 520.

connect a lead trap or pipe with an iron soil pipe or drain he shall insert between such trap or pipe and such soil pipe or drain a brass thimble, and he shall connect such lead trap or pipe with such thimble by means of a wiped or over-cast joint, and he shall connect such thimble with the iron soil pipe or drain by means of a joint made with molten lead, properly caulked." The joint between a leaden soil pipe and an iron drain was described in an earlier lecture, and illustrated by Fig. 295. In that case a copper thimble was described, and it may be urged that copper would last much longer than brass in positions where a corrosive action would set up. Good gun metal is far superior to brass for this purpose, especially when brass of the common "pot metal" description is used. The joint of a lead trap or pipe with an iron soil pipe is not quite like the one shown by Fig. 295. Assuming the iron soil pipe to be of the description given in the table, the connection would in

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some cases be as shown by Fig. 519. B is a leaden trap, C and E wiped soldered joints, D a short piece of lead soil pipe, F the brass thimble caulked into the socket of the iron branch G of the soil pipe. Joints in this position would be very difficult to make in a satisfactory manner, owing to the one usually made last, namely, the brass thimble to the iron, being in the centre of the wall. The joint in this position, but under the floor, has been mentioned in an earlier lecture, see Fig. 289. The proper position for these joints, and which is usually adopted by leading plumbers and engineers, is outside the building. Fig. 520 will make this more clear. In this case H is the lead pipe from the trap of the W.C., and J the brass ferrule with a wiped soldered joint to the lead pipe and caulked lead joint to the iron pipe. It is highly probable that, to meet the requirements of this bye-law, makers will manufacture special Y branches for iron soil

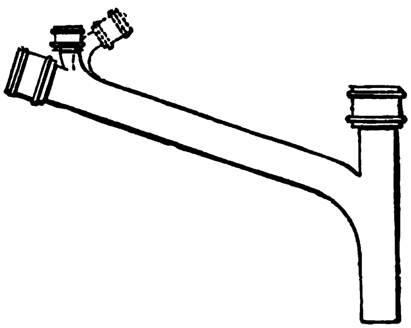

FIG. 521.

pipes, so that the caulked lead joint would be inside the inner face of the house wall, and thus do away with the short piece of lead pipe and joint, C and D, Fig. 519. If such iron branches are manufactured in the future they should have special branches for connecting the 2 in. trap ventilation pipe, so that a brass ferrule and soldered and caulked lead joints can be made as described for the soil pipe. Fig. 521 illustrates the suggestion. The branches should be bent as shown in the figure, for the reasons given when lecturing on lead soil pipes. The vent junction could be as dotted lines, so that the vent pipe would not be in the way of the service pipe to the W.C. basin.

For years there has been a question as to what should be considered the best method for jointing an earthenware fitting to a leaden pipe. Patents innumerable have been taken out for this, and some of them have been referred to in these pages. Figs. 456 to 462, inclusive, represent various kinds of joints, some patented, in common use for joining earthenware W.C. traps to lead soil pipes. A brass socket soldered on to the lead pipe is shown in section by the first named figure and referred to in the writing beneath. It is here re-drawn, Fig. 522, partly in elevation and partly in section, so as to make the construction more clear and to illustrate the bye-law which states : "In all such cases where he shall connect a stoneware trap or pipe with a lead soil pipe, he shall insert between such

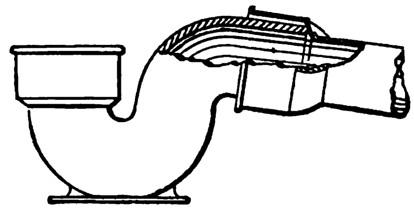

FIG. 522.

stoneware trap or pipe and such soil pipe a brass socket or other similar appliance, and he shall connect such stoneware trap or pipe by inserting it into such socket, making the joint with Portland cement, and he shall connect such socket with the lead soil pipe, by means of a wiped or overcast joint." By this latter phrase we may safely assume that the wiped joint is intended to be a "plumber's wiped soldered joint."

The joint of an earthenware trap to an iron soil pipe is described as follows: "In all cases where he shall connect a stoneware trap or pipe with an iron soil pipe or drain, he shall insert such stoneware trap or pipe into a socket on such iron soil pipe or drain, making the joint with Portland cement." Comment on this is not necessary beyond the statement that care must be taken when selecting a trap to be used. A great many of those in the market are much too short on the outgo so that it will not enter the socket the necessary distance for a reliable joint to be made without the risk of the cement escaping into the pipe, or leaving a hollow space in which filth can accumulate. The iron junction shown by Fig. 521 would be very suitable where a W.C. with an earthenware P trap was to be fitted, and the vent arm would be in the proper position to answer the requirements of the bye-law referring to trap vent pipes.

The final clause of this, the fourth, bye-law states : "He shall so construct such soil pipe that it shall not be directly connected with the waste pipe of any bath, rain water pipe, or of any sink other than that which is provided for the reception of urine or other excremental filth, and he shall construct such soil pipe so that there shall not be any trap in such soil pipe or between the soil pipe and any drain with which it is connected." Although some of the details in this bye-law have been referred to in previous lectures, we will briefly review some of them. The first being the question of a bath waste pipe connected to a soil pipe. The evils of this may be enumerated as follows. Baths are frequently left unused for a considerable length of time, and the water evaporated out of the traps allows air from the soil pipe and drains to escape into the house; hot water from

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baths frequently injures the soil pipes to such a serious extent that they have to be renewed in the case of lead and the joints re-made where iron is used; if any stoppage takes place in the soil pipe sewage will, in some cases, flow back into the bath or the safe beneath it; any air compression in the soil pipe will frequently result in intermittent smells in the bathroom. With regard to rain water pipes connected to soil pipes, the former almost invariably have the top ends situated near windows, roofs, and other openings into the house and drain air escaping from the pipe is carried by air currents into the house. In numbers of cases rain water pipes are supposed to act as soil pipe ventilators, but there are times, during a rainfall, for instance, when no ventilation can go on. Air cannot very well pass up a pipe at the same time that water is falling down, or through, it, and when ventilation is arrested several evils can occur. The third point mentioned in the bye-law refers to a very vexed question, namely, that of slop sinks. We will not now go into the whole details of these fittings, but just mention a few which bear on our present subject. When slop sinks are connected to soil pipes some of the evils occur as mentioned when dealing with bath waste pipes. But slop sinks used for receiving excremental filth cannot be treated as ordinary sinks, by disconnecting the waste pipes from the drains. The sinks under these conditions must be looked upon as water-closets, and be treated in the same manner. That is, they should have waste pipes fixed under all conditions as soil pipes; or the sinks should be connected to the soil pipes, and have flushing cistern attachments. In these cases there should not be any hot water taps fixed over the sinks. But it would be much better not to have slop sinks for receiving excremental filth. There are numbers of water-closets made with "slop tops" to them especially for the purpose, and they should be used. These remarks apply to private houses only. Infirmaries, hospitals, and such establishments, require especial treatment. Slop sinks used for ordinary waste water and bedroom slops, containing only a small percentage of urine, should have separate waste pipes, disconnected from the drains, and not be connected to soil pipes.

The portion of the bye-law relating to traps in soil pipes must not be taken as it reads, as, if so, there would not be any traps under the W.C.'s. The meaning of the sentence is that the soil-pipes shall be connected to the drains without the intervention of any traps at the points of junction. Authorities do not all agree on this matter, but with this we have nothing to do. Our duty is to obey the law as it is laid down.

The foregoing bye-laws refer principally to new constructions. Repairs and alterations to old, or existing work have to be carried out on the same lines as for new work. This is provided for in the fifth bye-law, which reads as follows: "A person who shall newly fit or fix any apparatus in connection with any existing water-closet, shall, as regards such apparatus and its connections with any soil-pipe or drain, comply with such of the requirements of the foregoing bye-laws as would be applicable to the apparatus so fitted or fixed if the water-closet were being newly constructed." This regulation is very far reaching, and there may be some difficulty in gauging its full extent.

To explain this, we will assume that a W.C. apparatus with a "container or other similar fitting" falls out of repair. The plumber is expected not to "newly fit or fix" this apparatus, as it is not in accordance with the stipulations contained in the third bye-law. As pan closets and D-traps are generally found together it follows that the trap must also be renewed or changed for one of a better description. The term "newly fit" may, perhaps, be intended to apply to any kind of repairs to an objectionable W.C. fitting, and if so, it may mean that no plumber must attempt to do any kind of repairs to such fittings. To carry this to an extreme, it may be urged that if a pan W.C. flushed by means of a service-box, with cranks and wires, should have one of the wires broken; the wire ought not to be repaired, but the whole of the fitting should be changed for one that is more satisfactory and conforms to other bye-laws. Even if this is going beyond the intentions of the authorities, which is doubtful, it is not too drastic in its working. The slightest reason should be sufficient for getting rid of anything that is injurious to health. The bye-laws are drawn up for the especial purpose of improving the public health, in this our own is included, and they should not be evaded in any way.

Several of the bye-laws which follow the last one we have dealt with, have no reference to plumbers' work, so we need not deal with them. The next one of interest to us is the fourteenth, which states: "Every person who shall intend to construct any water-closet, earth-closet, or privy, or to fit or fix in, or in connection with any water-closet, earth-closet, or privy, any apparatus or any trap or soil-pipe, shall, before executing any such works, give notice in writing to the clerk of the Sanitary Authority." A first reading of this bye-law leads one to think that notice to the clerk of the Sanitary Authority is only necessary to be given when entirely new work is being contemplated; but on a second reading it appears as if this notice was necessary in all cases, including old work which it is found necessary to renew either in the whole or in part. This latter reading may not be quite right owing to the absence of the word "existing" after the second word "any," in the sentence. The only way to clear the matter up will be to give notice and apply to the Sanitary Authority for their interpretation of this bye-law. This is a very wise precaution to take, and is made more impressive by the final, or

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28th bye-law, which deals with penalties, and reads as follows: "Every person who shall offend against any of the foregoing bye-laws shall be liable for every such offence to a penalty of five pounds, and in the case of a continuing offence, to a further penalty of forty shillings for each day after written notice of the offence from the Sanitary Authority. Provided, nevertheless, that the Court before whom any complaint may be made, or any proceedings may be taken in respect of any such offence may, if the Court think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this bye-law." This clause is very far reaching, and may be read as including the person for whom the work is executed, the person engaging to do the work, and the workman who executes the work. If this reading of the bye-law is correct it behoves all concerned to be careful as to their proceedings, and, so that they shall not err in ignorance to always consult the proper authorities before proceeding with any work that is dealt with in these bye-laws.

We will now proceed to deal with the fixing of a valve W.C. apparatus and all the details in connection therewith. Fig. 523, which represents

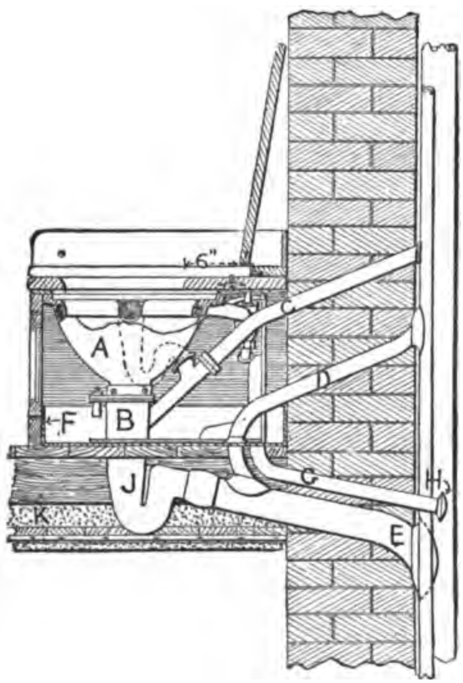

FIG. 523.

one in a tier, will help to make the subject more clearly understood. The apparatus, A, is similar to that illustrated by Fig. 479. The valve box, B, has a ventilation pipe, C, which is generally known as a "puff-pipe," continued through the external wall to the outer air. The outer end of this pipe should be slightly opened with a tanpin and two copper cross wires soldered over to prevent anything getting in. Some plumbers will work a small bead on the end of the pipe to give it a more finished appearance. The pipe should be fixed sloping as shown in the figure and the outer end should be higher than the top of the W.C. If this is not done the outrush of air, when the basin is flushed, will sometimes carry a small quantity of water with it. On no account should the puff pipe be connected to the soil pipe or trap vent pipe. Several times the writer has found this done, and when testing a soil pipe with smoke has found the smoke escape through the W.C. when the discharging valve was opened. Such connection renders the trap under the apparatus perfectly useless as the puff pipe acts as a by-pass for foul air to escape through. The trap vent pipe, D, and the branch soil pipe, E, should have the ends bent near the joints so that the junctions may as nearly as possible approach the shape of bends. This has been referred to before and illustrated by Figs. 287 and 288. Where the floors, under the W.C., are not made of impervious material, which is very rarely the case, they should be covered with sheet lead. These coverings are called "safes" or "save-alls." Four or five lbs. lead is quite thick enough for this purposes. The safe should be made to cover the whole of the floor inside the W.C. enclosure. That is, the lead should be close up to the side and back walls, the sides standing up at least 4 in., and the front at F dressed up close to the front, or riser. If the latter is not done any water, or urine, getting between the basin and the riser will run down onto the floor. This is a frequent cause of complaint, with a great many water-closets of all kinds, the saturated woodwork smelling very offensive. The riser, too, is sometimes saturated, but this will be dealt with presently. The floor under the safe should be laid to fall to one of the back corners, this corner not being near the flushing valve, and a waste pipe, not less than 1½ in. in diameter, fixed as shown at G. The joint of this pipe to the safe should be flush, the woodwork beneath being dished for this, so that any leakage or overflow from the apparatus will run to and through the waste pipe. The safe should have a flush soldered joint to the W.C. trap. Some plumbers will trust to the putty used, when bedding down the W.C. apparatus, for making this joint tight, but this makes but a poor, unsatisfactory job. The usual practice is to fix a hinged copper flap on the end of the waste pipe at H, but this is far from being a good plan to adopt. The hinge of the flap will frequently become rigid, even a slight hoar frost is sufficient for this, when the waste pipe becomes useless. To prevent a strong current of cold air passing through, which in the winter time will sometimes lead to the water supply pipe, or flushing valve, being frozen, a copper hood can be fixed over the end. This is sufficient to pre-

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vent a violent draught but will allow air to enter and help to ventilate the space beneath the W.C. enclosure. This air cannot escape in any position to be unpleasant to any user as will be described when we deal with the enclosure.

When discussing the London County Council's bye-laws, mention was made that the walls or partitions of water-closets should be so constructed that no smells could pass through. It is equally important that the floors should also be air-tight. In addition to this the space round the trap, J, should be well packed to prevent the rushing noise, made by the water when the W.C. is used, being heard on the floor below. This noise is sometimes very startling and unpleasant and because of it squeamish people do not always flush the apparatus after them. To deaden the noise, and prevent it being heard below, it is usual to "soundboard and pug" the floor, as shown at K.

When fixing valve W.C. apparatus in new buildings the plumber should always consult the architect's plans before proceeding to fix the traps. Otherwise the joiners' work will not fit the plumbers' work. The plumber should also have a sample of the apparatus to work to. The reason for this being that with a great many valve W.C.'s the centre of the outlet is not under the centre of the basin. The greater number vary from ½ in. to 1 in. in this, and it may be accepted as a general rule that, to suit the apparatus, the trap should be fixed about 1 in. nearer the left hand side of the closet, when facing it, than the other. The centre of the basin will then be equi-distant from the side walls and the opening in the seat will correspond with it. Where there are no architect's plans to work to the plumber should then use his own discretion in the other details. One of the first of these is the distance the trap should be fixed from the back wall. Generally speaking this distance is too short, and very rarely exceeds 13 or 14 inches. This would answer fairly well where there are no flaps to the enclosures. These flaps are of little use and could be abandoned with advantage in all cases excepting when fixed in bathrooms, but where there are flaps there should always be room for the user's dress between the holes in the seats and the flaps. A space of about 6 in. should be left, see Fig. 523, and it will be found that to get this the centre of the trap should be fixed from 16 in. to 17 in. from the back wall. It is not generally known by the joiners, who fix the W.C. enclosures, but the plumbers should point it out to them, that the shape and size of the holes have an important bearing on the cleanliness of the W.C. basins. The subject is one too delicate to dwell upon or to illustrate, and it must be sufficient to say that although the hole must be large enough for comfortable usage, it must not be too large so that the sides of the basin can be fouled. And neither should it be so large that childrens' bodies can project through the opening. When children use adult's W.C.'s it is often found necessary to have removable seats with small holes to place over the ordinary seats. The riser is generally made upright, as shown in the figure, and hung on brass butts for easy access to the W.C. fittings, but when the lower edge is further back, so that the riser is sloping, the user's heels can be tucked under and thus make the whole fitting more comfortable to use, especially by people of tall stature. When the riser is as suggested, it should be fixed with flush brass bolts instead of hinges and have a lead apron piece to lap over the front edge of the safe. The whole of the bearers and undersides of the enclosure should be painted, varnished, or otherwise rendered impervious to moisture. The seat should be arranged as shown by Fig. 523, wood beads being fixed round the basin and bedded down both air and water-tight for reasons that suggest themselves to the reader.

In the lectures on "setting out plumbers' work" was described how to show the traps and soil pipe for a range of three W.C.'s. This was illustrated by Fig. 108. There are several details in this problem that have not been considered, and we will now deal with them, taking the evils that we almost invariably find with regard to the position of the W.C.'s and their general treatment. In the first place, ranges of W.C.'s are very rarely, or never, fixed in private houses, but in hotels, sets of offices, railway stations, or places of public resort where people of both sexes are in the habit of attending. Separate conveniences are almost invariably provided, and also separate entrances for each sex, but decency is frequently outraged by placing the gentlemen's and ladies' W.C.'s so that they adjoin each other, and are divided by thin partitions or defective walls which neither prevent sound nor smell passing through. In numbers of cases ranges of W.C.'s are found with long lead safes extending the whole length of the ranges and the partitions or walls not continued down to the floors, but having openings for anything that escapes into the safes to flow away to the outlets or waste pipes, which are generally fixed at the end of the safes. These openings are the evils pointed out above. Again, even when the places are used by one sex only, it is not at all pleasant when visiting those that have the partitions dwarfed instead of being continued to the ceilings. Every W.C., either single or connected with a range should have a separate entrance, airtight partitions or walls, safe, ventilating arrangement and light. With regard to the latter, numbers of W.C.'s are found with scarcely any light, or perhaps with light borrowed, as it is commonly expressed, from another W.C. or an adjoining room, or from a lobby or common entrance to all the W.C.'s. In what has been said it was assumed that W.C. apparatus with enclosures to them were used. With unenclosed apparatus some of the evils enumerated would be visible and not

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allowed to exist. There is not the least doubt that the day will come when enclosures to W.C.'s will be considered as big nuisances as were "pan" closets. To explain why, we may take some of the writer's personal experiences. In workhouses, small bottles which had contained spirits are sometimes found under the enclosures; in theatres, railway stations, exhibitions and similar places, empty purses, bags, and other things; in police cells, small articles that doubtless had been stolen; in hotels have been found indescribable articles too numerous to enumerate; in private houses, various matters that the servants are anxious to keep out of sight. From the sanitary aspect, the practical plumber has frequent experiences where he has been sent for to find out the cause of smells in W.C.'s, and has found the enclosure, apparatus, floor or safe, and all in connection covered or saturated with slops. But for the enclosure all these objectionable details would not have occurred. No doubt the reader remembers that in an earlier lecture the writer stated that he considered "valve W.C.'s" as the best and preferable to all others and illustrated one with a square top to the basin (see Figs. 479 and 523), and will have some difficulty in reconciling the use of valve closets and the absence of enclosures. To remove this difficulty it may be here stated that the same apparatus, slightly varied in form, and without any enclosure, has been fixed in large numbers for some years past by one of our leading firms of sanitary engineers, thus showing that the idea is not an original one of the writer's. When such W.C.'s are fixed the necessity still remains for making the floor impervious. There are various ways of doing this. If the floor is wood it can be covered with lead. The back and sides being nailed to the skirting if made of wood, or the top edge turned into the plaster, if that material is used on the walls, and the front edge dressed over and copper nailed to a raised fillet fixed to the floor. The fixing to the wall is not usually done, and water frequently gets behind the safe and leaks into lower rooms. A waste pipe fixed from the lowest corner to empty into the open air, and a brass grating, with a good waterway through

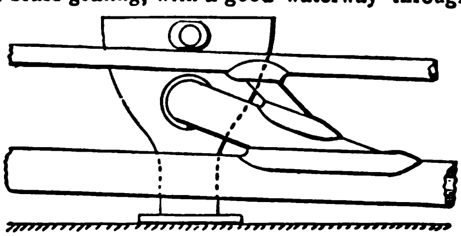

FIG. 524.

it, soldered over the pipe end in the safe. Where the closet floor is tiled or covered with mosaic paving, this is generally continued under the apparatus. This paving answers very well in private houses, but in places used by large numbers of people it is objectionable, especially when the W.C.'s are used as urinals. The floors get saturated with droppings and smell very offensive. Sometimes the space beneath the apparatus is covered with a marble slab, the surface being dished to fall to one corner, from which a waste pipe and grating is fixed. The marble may look very nice, but when of a soft kind it will become as offensive as the last floor described. There is nothing better for this purpose than a good close-grained slate slab, although in appearance it may not look equal to marble or tiles.

A variation of the problem shown by Fig. 108 is where ordinary pedestal W.C.'s with the traps attached to the basins are used. In buildings with so-called fireproof floors it is generally

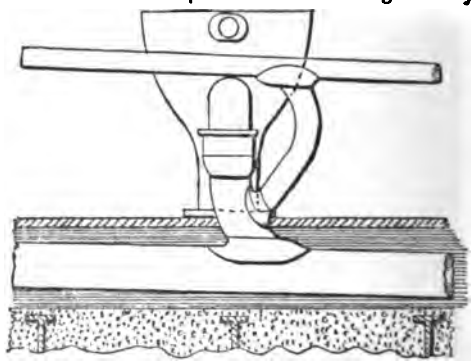

FIG. 525.

considered inadvisable to mutilate the floors or do anything that would militate against their purpose. With valve apparatus the traps must be above the fireproof construction, and in some cases it becomes necessary to have a step up to the W.C. when such apparatus is used. Some architects will have a portion of the fireproof flooring constructed at a lower level so as to avoid the necessity of a step. With the pedestal basins, as shown by Figs. 454 and 519, it is not necessary to cut away the flooring, nor to have a step. With fireproof floors it follows that no perforations should be made for the vertical soil pipe to pass through. In large numbers of cases it is impossible to avoid this, owing to the walls at the back of the closets not being outside walls. In such a case the horizontal soil pipe for a range of W.C.'s would be fixed in sight, or if that was objected to a false floor, with a step up to it, must be made, and the soil pipe fixed beneath it unless the floor is sunk lower, as above described. It may be added that if the horizontal pipe is above the floor its unsightliness would be aggravated by the ugly appearance of the branches and difficulty of connecting the W.C. traps, even if they were especially made for the purpose.

Fig. 524, which is a view from the back, will make this more clearly understood. Even with a range of three W.C.'s the horizontal pipe would

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have very little fall and with a longer range this would be further reduced. Neither could the trap vent pipe be fixed so as to look smart.

With a false floor, a space between it and the fireproof floor, and the horizontal pipe fixed between the two the plumber's work would appear as shown by Fig. 525, which is also a view from the back of the closet. With fireproof floors, which are also waterproof, it is not absolutely necessary to have safes under the W.C.'s. Although, when the floors have a spongy surface it may be deemed advisable to fix them. But when false floors are fixed over the fireproof, and are made of wood, the safes are absolutely necessary.

When a range of W.C.'s is fixed against an external wall the horizontal soil pipe can then be fixed outside, and this is now the common practice. Architects do not care to have their buildings disfigured with outside pipes, and those fixed horizontally cannot be considered, no matter how tastefully the plumber may arrange and fix them, as things of beauty or anything else than right down ugly. But with this we have nothing to do. The time may come when a protest may lead to an alteration in the regulations, but until then we must obey the rules laid down.*

The writer has had several experiences of outside soil pipes, and by Fig. 526 has illustrated one of four stacks recently constructed. The figure speaks for itself. All the horizontal, or more properly speaking, sloping, pipes are fixed one inch clear of the walls. It may here be again repeated that dust, &c., will lodge on the top of any horizontal pipes, and a shower of rain will wash this dust down the face of the wall, making unsightly black looking streaks whenever the pipes are fixed close to it. When the pipes do not fit close to the wall the dust falls down and the streaks are avoided. The closets used are of the short hopper washdown description, with lead P-traps, and all the joints are what are called plumbers' "wiped" soldered joints. The trap vent pipes are soldered to the branch soil pipes a few inches away from the outgoes of the traps. In some cases the main stack of ventilation pipe is 3 in. and 4 in. in diameter, with 2 in. short branches to the traps. In other cases the whole of these vent pipes are 2 in. in diameter, and answer very well indeed. But this pipe would be much too small where valve W.C. apparatus are used, or where a slop sink is attached to the same soil pipe. See previous lectures for the reasons for this.

When cast iron soil-pipes are used for ranges of W.C.'s, and these pipes are fixed outside, it is usual to have short pieces of lead to connect the W.C. traps to the soil-pipe. Fig. 527 is an illustration of the outside horizontal soil and trap ventilation-pipes for a range of three W.C.'s. The lead being connected to the iron by means of brass thimbles, A, A, with wiped soldered joints to the lead and caulked metallic lead

* This refers to the London County Council's regulations.

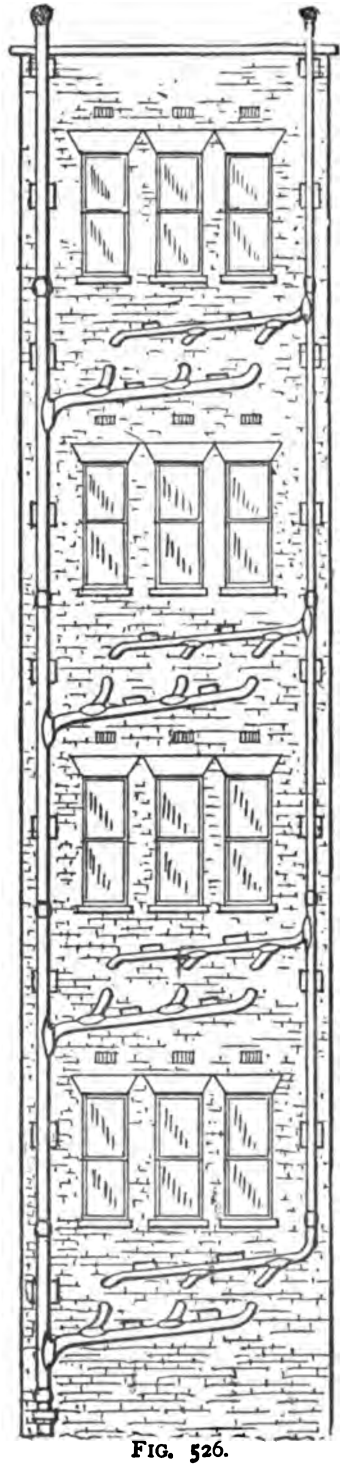

FIG. 526.

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joints to the iron pipe. As in Fig. 526, the trap ventilation-pipes are made of lead, the branches being connected to the lead soil-pipes by wiped soldered joints. Attempts have been made to use all iron and not to have lead for either soil or ventilation-pipes, or for making connections with the W.C. traps. The result has been a patchwork looking job and an excessive cost for especially made iron castings to suit the work being done. If the horizontal pipes were per-

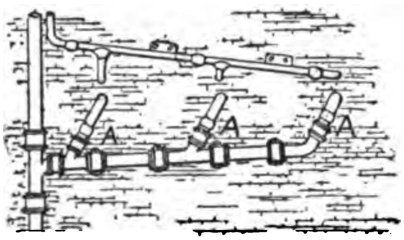

FIG. 527.

fectly level the task would be an easy one, but as this pipe must have a fall towards the outlet the branches must be made to suit the fall, and this applies to both soil and trap ventilation-pipes. Then again, if iron were used for these ventilating-pipes the sizes would have to be increased above those when lead is used, owing to the excessive friction of the air passing through, the rough internal surfaces retarding the velocity. Neither is iron to be trusted, in the same way as lead, for ventilation-pipes, owing to the amount of corrosion that takes place inside. Galvanising is only of temporary value, and all the known protective agents are of little or no use. It is generally thought that any material is good enough for soil or drain ventilating-pipes, as nothing but air passes through them. But this is a mistake. It is not always pure air that passes through. Certain gases that emanate from sewage, especially when in a state of de-

blocks up the pipe, the blockages generally being found at the bends and horizontal junctions. Some plumbers will fix boxes, commonly called "rust catchers," for the reception and easy removal of the rust accumulation. When water passes through iron pipes with sufficient force any iron rust is washed away. With ventilation-pipes this does not take place. Iron pipes are continually being found to be useless owing to their being so choked.

An example of a job with cast iron soil-pipe for a range of W.C.'s, the horizontal part being fixed inside the buildings, is shown by Fig. 528. The illustration represents an elevation from the outside, as would be seen if the back wall were removed, of one range, others being fixed on the floors above and below. All the branches, B, B, being cast from the same especially made patterns. The end one at C being a bend with a junction for connecting a ventilation-pipe. This junction is kept up close to the socket and has a bend arranged, as shown, to prevent any back wash from the W.C., choking it up and thus rendering it useless. The short pipes, D, D, are all cast from the same pattern and have the sockets especially made to fit the outlet legs of the earthenware W.C. traps. These pipes being reduced to the lengths required by means of "cutters." Fig. 529 is an illustration of these and anyone who has much cast iron pipe to cut should use them. They soon repay their cost by the saving on files. The pipes are cut to any exact length and the cut ends are perfectly true. When cutting those shown at D, Fig. 528, and they are very short they should be fixed on the end of a scaffold pole, by means of wooden wedges, to hold them rigid. A pipe-vice, as shown by Fig. 530, can be used for the longer pipes. The scaffold pole is a very good substitute and can be fixed in the pipe-vice when one is at hand and occasion requires it.

At E, E, Fig. 228, are doors or caps, which can be taken off and rods pushed through the

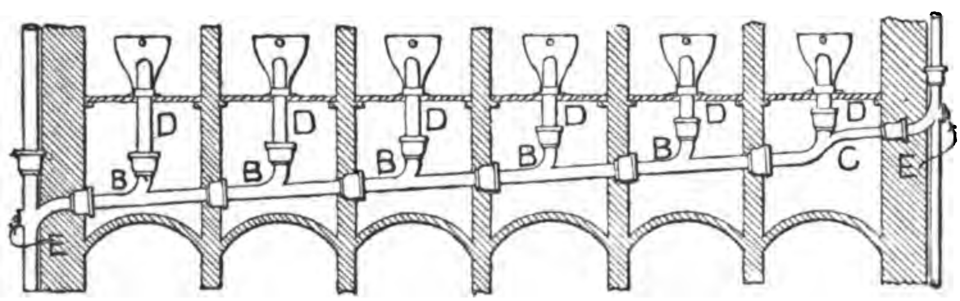

FIG. 528.

composition, have a corrosive, or destroying, influence. But a more powerful agent is watery vapour, which condenses and runs down inside. This, what may be called distilled water, highly charged with air, corrodes metals to a very serious extent. In the case of iron the rust peels off and eventually falls downwards and

horizontal pipe for the removal of obstructions. Some of these junctions with doors are bought from stock and have the caps hollow on the inside. These hollows are objectionable, as filth can accumulate in them. The doors or caps should have the inner faces flush and hollowed to suit the inside of the pipe. Some

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warehouses keep such fittings. No trap vent-pipes are shown in the figure as none were fixed in the case from which the illustration is taken. The whole of the soil-pipes were fixed before the floors were laid. These floors are

FIG. 529.

1¼ in. slate slabs, resting on projections or corbels built into the walls. The slabs have Portland cement fillets round the edges and also round the sockets of the iron pipes to prevent slops or water running through into the space beneath. The horizontal soil-pipe and branches were heavy cast-iron about ½ in. thick, and all the joints made with metallic lead. The joints of the W.C. traps to the iron sockets were made with especially made elastic cement. Before fixing the W.C.'s all the openings were plugged and the pipes filled with water to test their soundness.

American practice is not quite the same as our English in several things, although a great many of the principles on which sanitary work is constructed are the same in both countries. One great difference is the treatment of waste water-pipes. Our English practice is to make them empty into or over gully-traps fixed out of doors. Not so the American.

Owing to the extreme cold at certain times of the year it would be impossible to follow out the disconnection of waste-pipe principle. In that country it is the usual practice to connect all waste-pipes from baths, sinks, and wash-basins to the soil-pipes. If these latter pipes were made of lead they would last but a very short time, owing to the expansion and contraction caused by hot and cold water discharges breaking the pipes. This, doubtless, is the reason that iron soil-pipes are the rule. The various connections of soil and water-pipes are made to branches, cast in the main soil-pipe, by means of short lead pipes, with brass ferrules caulked to the iron and soldered to the lead-pipes respectively, as in our English practice. When the main stacks of ventilation-pipes are made of iron the various trap-vents are connected in the same manner as the branches from the W.C. sinks and baths to the main soil-pipe. In most American towns all the joints must be made as above described, and so-called cement-joints are entirely forbidden. In this latter detail the American may be considered far superior to our English practice as followed by the class commonly known as "jerry," and also by some practitioners who, to say the least, have not considered this matter in all its bearings. In America the soil-pipes are generally made of cast-iron, and in each of the principal towns, printed regulations, which contain the weights to be used, are issued for the guidance of plumbers and others interested.

One large American firm make a speciality of wrought iron soil and waste-pipes and fittings, all the joints being screwed and coupled together with sockets similar to the smaller sizes used by us for water and gas. Attempts have been made to introduce this class of work into this country, but the writer does not know with what degree of success. At an interview some years ago with the agent for the firm he was told that the whole of the work could be prepared at the manufactory, taken to the building, placed in position, screwed together, including the various traps, and the whole com-

FIG. 530.

pleted and fixed before the floors were laid. The whole, being so strong and rigid as to be self-supporting and, excepting the walls, independent of the rest of the building.

In some of the leading American towns it is usual to apply the water test to all soil-pipes, as well as the drains, and this is now becoming common practice with some of our leading plumbers and sanitary engineers. Years ago the writer advocated this way of testing soil-pipes and frequently applied it. He also considers this the only test that will drive jerry and inferior work out of the market. The theory is sometimes advanced that this test is an unfair one, and that the pipes and connections are

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never in practice subjected to such a strain. People who argue thus forget that the soil-pipes are sometimes choked and filled up with sewage. In such cases the plumber's work is subjected to the water test, and when of good construction successfully withstands the strain, although an inferior class of work breaks down.

We have now arrived at a stage when a change of subject is desirable. Water-closets, with their attachments, are of such a variety, and dealt with as problems become so interesting that one reluctantly leaves their considera-tion for something else. We have dealt with most of the leading points in connection with them, both in these lectures and my book, "Plumbing Practice," and at a future time may traverse the subject by dealing with unsanitary W.C. arrangements with examples taken from actual practice. We will now pass on to "baths," their fitting and arrangement.

BATHS.

UNDER this heading it is proposed to deal only with those in which plumbers are interested, taking first the ordinary "plunge bath." First with regard to shape and size. The two commonest shapes are those known as "taper" and "parallel." The latter are the most liked, there being more room for the bather to move about than in the others. More water is required for this bath than for the tapering one. This is an important item where water has to be used economically, or, in cases where the hot water supply is not good, and there is trouble in getting a hot water bath. Crochetty clients have objected to tapering baths under the plea that they resembled coffins in shape. Neither do tapering baths look so nice as the other kind, either when enclosed or fixed without any enclosure. To sum up what has been said, parallel baths should always be used, excepting when the water supply, either hot or cold, is limited, in which cases the tapering baths should be used.

The size of a bath is an important detail. A bath should never be so long that the bather cannot press his feet on the bottom end when recumbent. Cases are not uncommon where a person has been drowned in a so-called plunge bath. If a feeling of faintness overtakes a person when bathing, especially when having a hot bath, and he slips down below the water he risks being drowned, but when the bath is of such a size that when the feet are pressing against the bottom end his head is resting against the opposite end and above the water level the risk is much reduced. A person measuring 6 ft. in height can bathe comfortably in a bath which measures 5 ft. 6 in. long inside the top edge. For ordinary usage by people of average height a bath 5 ft. 3 in. long at the top is quite sufficient. The bottom measure in each case being about 15 in. or 16 in. shorter than that at the top. The foot of the bath should be nearly vertical, but the head should be sloping at a comfortable angle for the bather to rest the body against. If this end is too upright the bather's head is pressed onto the chest and the breathing interfered with. This becomes worse when the knees are raised for the purpose of further immersing the body.

The width of a bath has to be considered in cases where the probable users are of stout build. Some of the cheap kinds are often complained of as being so narrow in the bottom part that bathers have been wedged in. The writer has had to exchange such fittings for others which were more roomy. In a few cases he has fixed them made of copper of the following dimensions: Length inside at the top, 5 ft. 6 in.; at bottom, 4 ft. 4 in.; width at top, 2 ft. 6 in.; at bottom, 1 ft. 9 in.; the depth being 1 ft. 8 in. in the deepest part, which is at the foot. Such a size is very comfortable to bathe in. Much larger baths are sometimes used, but it is a mistake to go to extremes in the sizes of such fittings. One crotchety client has them made almost large enough to swim in, they being about 7 ft. × 4 ft. × 2 ft. 6 in. deep. People who are in the habit of using cold water baths prefer them of a good size. Speaking from experience, the writer prefers to plunge into a good size cold water bath than to crawl into a small one. In one case it is enjoyable, in the other it is not so. For ordinary use a parallel bath 5 ft. 3 in. long inside at the top, and 4 ft at the bottom, by 2 ft. 4 in. and 1 ft 9 in. in width at top and bottom respectively, is very comfortable for use.

The depth of a bath is also worth considera-tion. As a matter of fact, large numbers of people never think of comfort when either buy-ing or fitting them up. As an example, how uncomfortable it is to step into a bath the bottom of which is below the level of the out-side floor, or into one when the bottom is some distance above the floor. To adapt a saying by an actor in a play popular some years ago, "How unpleasant it is to sit down six inches before you know you are going to sit down," and it is equally unpleasant to step into a bath of unknown depth. Of course, this

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applies only to the usage of strange baths. People get used to little peculiarities in their own domestic arrangements. When fitted up, the top should not stand more than about 1 ft. 8 in. above the floor, and the bottom of the bath should be level with the floor. When so arranged it is very easy to step in, provided the wooden top, when one is used, is not more than 3 in. or 3½ in. wide. When baths are fixed, as they sometimes are, about 2 ft. 4 in. or more above the floor, they should have wider rims so that the bather can sit on the edge and throw the legs over into the water. But when the body is wetted this is not so easily done when getting out of the bath. To make it easier for getting out, it is a common practice to put a step outside the enclosure. This is not at all a good plan to adopt, as a bather with wet feet can slip and be injured. With these points before us we can assume that a bath 1 ft. 8 in. deep in itself, and having a depth of water of about 1 ft., is about right for all round usage. In special cases they can be larger. As examples, in large schools, such as the Foundling, and similar institutions, where it is a convenience to bathe two or three children at the same time, the baths should be longer and wider than usual but the depth should not be increased. In private houses, it has been suggested that those of a small size should be fixed for the children's use. An objection to this is the children will grow in size—eventually requiring full-size baths—and after a few years it would become necessary to reconstruct the whole of the fitting. Neither should a young child use an adult's bath, excepting under the superintendence of a nurse or maid. A shallow, portable one is much more suitable for such a case. It is impossible to lay down fixed rules for the sizes of baths for all purposes, but with the above as a guide, the reader can form a better opinion than he would without some such basis to work upon.

We will now deal with materials for them. Plumbers do not now make them of lead, as was the common practice, especially in country places a few years ago. A great many of the cheaper kinds are made of light sheet zinc, which is about the most unsuitable material that can be used. Such baths, after they have been in use for a short time, invariably present a wretched, dilapidated appearance. Even when supported by a wooden framing, called "cradling," the sides will become distorted and the bottom sunk into bags so that the water will not all flow away to the outlet. The reason for this arises from the action of the hot water, which softens the zinc to such an extent that the pressure of the contained water, added to that of the bather, presses the material outwards and downwards in every part not supported by the cradling. This latter not being close boarded and in contact with the outside of the bath in every part, as it should be, but being a kind of skeleton framing, does not sufficiently resist the internal pressure, with the results above named. When zinc is the material used it should never be less than ⅛ in. in thickness. Such baths are made and much used in the North of England, and a few find their way down South. When made of zinc of this substance they do not require any cradling or other support of any kind. They can be made to any special size and form. Fig. 531 is an example of one of several fixed in London, although made in Scotland. The skirting at the back and one end, the top, with a bold rounded nosing in front and at the other end, are all made of the same material as the body of the bath. These fittings do not require any enamelling on the inside. When kept clean and well scoured, so as to present a bright appearance, they look very nice, but when neglected their appearance is not so good. As the labour of keeping them clean is very considerable it is best to paint or enamel them on the outside when they are to stand without an

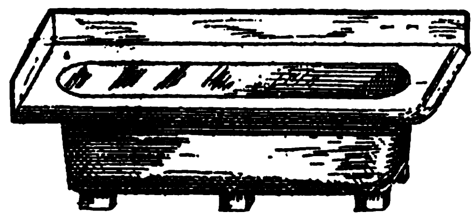

FIG. 531.

enclosure, but when encased the enamelling is not necessary.

For cheap work tinned iron baths are sometimes used, and are much better than those made of light sheet zinc so far as keeping their shape goes. But as soon as the enamelling is worn off the iron will begin to rust, especially at those parts where the tin has been scraped off when removing the surplus solder at the seams, and at the holes or perforations, when so arranged, over the waste outlet. Because of this latter some makers of tinned iron baths will insert a copper strainer in the bottom over the waste pipe. These are also made to fix inside enclosures or to stand without. In the first case the top edge has a flat rim, and in the latter a so-called "rolled" or rounded rim.

During these last few years those made of steel have been much used. They are very similar in shape to ordinary stock patterns of tinned iron baths. The writer has never fixed any, but when making examinations of houses he frequently comes across steel baths, and speaking generally they have appeared to wear much better than those made of tinned iron.

A still later introduction is a steel bath with a tinned copper lining. The tinned surface of the copper being so highly polished as to appear almost like silver. Not having had any actual experience with this kind no comment can fairly be made of its qualities.

Cast iron baths are now very much used. The better kinds will stand a great deal of hard

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wear and usage, and can be had in a variety of forms. Some of the cheaper kinds are objectionable with regard to shape and size. The enamelling, too, is often so roughly finished, and such indifferent materials used, that it soon wears off. The iron being exposed and unprotected rusts and looks unsightly, in addition to being uncomfortable to the user. Cast iron baths can be had for fixing in enclosures or to stand alone. One advantage in their favour is they never get out of shape, and do not require any cradling or support to prevent the sides and bottom from bulging outwards.

Copper baths are more used than any other kind for what may be considered as best work, not the poor light ones often met with, and which are very little better than light zinc or tinned iron for resisting internal pressure, but good strong baths made out of sheet copper weighing two to two-and-a-quarter pounds per superficial foot, or about Nos. 19 or 18 Birmingham wire gauge. When properly made these would last almost for ever, and the enamelling could be renewed as often as it became shabby-looking.

A word or two on so-called "enamelling," sometimes known as "japanning," baths. The article is coated with ordinary lead paint, ground in oil, and mixed with copal or other suitable varnish. The bath is then "stoved," that is, placed in a closet heated to a very high temperature to thoroughly dry the paint, which is then "rubbed down," as painters call it, and a fresh coat applied on the top of the other when the stoving is repeated. According to the quality of the work successive coats are added, and finally two, three, or four coats of copal or animé varnish without driers are put on and dried. The stoving is an important detail. Unless this is thoroughly done, and at a temperature much higher than boiling water the enamelling will soon come, or wash, off in the bath. When one is sent to the enamellers to be re-coated, plenty of time, say two to three weeks, should be allowed for the operation. If too much hurried the result is not at all satisfactory. The best makers are very particular in this matter, and when good materials are used and plenty of time allowed, the enamelling will expand and contract, with the varying temperatures of the water, to the same degree as the metal work of the bath. If the enamelling does not expand and contract to the same degree as the metal, it will crack and look unsightly after being in use but a very short time. Baths enamelled inside should not be left with the water standing in them. Even a piece of wetted soap left in the bottom will have an injurious effect on the enamelling. Another kind of bath is made of cast iron and is "porcelain" enamelled inside.

This is a white glazed coating which wears very well indeed, and with fair usage, lasts a considerable time. If a small piece of the enamelling gets chipped off the iron will rust. The rust extending will burst off other pieces of the enamel until at last the whole looks very unsightly indeed.

All the baths that have been described are used principally in private houses, although some are in use in hospitals and such like buildings. In those places, including Public Baths, the fittings have to withstand a lot of very hard wear, and what may be called "knocking about." In Public Baths, which are well regulated, the attendant, by the aid of a long-handled brush, scrubs the sides of each one after being used. When excessive vigour is employed and the bath is not of a very strong description it will soon wear out or become injured. For the Institutions above referred to there is nothing equal to the so-called "white enamelled fireclay" baths. Fig. 532 is a sketch of such a fitting. The sizes nearly approach those given above for what was called a comfortable one. The writer considers they would be more so if the head part was made more sloping, so that the back of the bather was supported by it, and the shoulder part increased in width. The length, 6 ft. outside and 5 ft. 7½ in. inside, is suitable for tall people; but shorter sizes are made, and would be better for people of medium stature. Taken altogether this make, so far as size goes, is much better than a great many of those made of iron. A few of these fireclay baths are used in private houses, but they are not much liked on account of the time it takes to warm the material. When a hot bath is required it is necessary to partly fill it with hot water some time before using, so that the bottom and sides will get warm, and then cool the water down to the required temperature by adding cold. It is not at all pleasant to get into a hot bath and

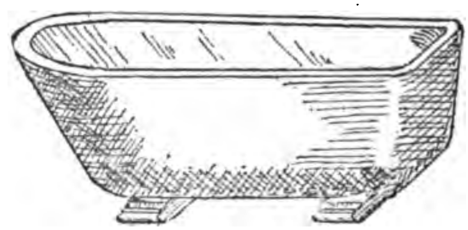

FIG. 532.

come into contact with a cold surrounding. To prevent this, some bathers will place a towel in the bottom to stand upon. The weight of these baths is also considerable, and varies according to size, from about 5 to 7 cwt. In some cases the weight of the bath, added to that of the water used, and also the bather, would approach to 12 or 13 cwt., so that when using such a fitting the strength of the floor supports should be carefully seen to. A word of caution may here be given to those who have to fit up those of this kind. It is not at all uncommon to find them crack in the bottom and end, the fracture commencing at the waste or

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overflow holes. This arises from the brass connections to the waste and overflow-pipes fitting too tightly. On becoming heated, the brasswork expands with sufficient force to break the fireclay through. When buying this kind it is always a good plan to have the brass connections also from the same firm, who, for their own credit's sake, would fit them properly and be responsible for any breakage. Those who prefer to use their own brass connections should send them to the bath makers, to have them fitted properly. The writer refers to this matter as he has known plumbers to be blamed for these breakages.

There are other baths used at times besides those described above. Amongst the rest may be mentioned a nice-looking one made of vitrified stoneware, similar to some kinds of best quality drain-pipes, with an enamelled inside surface. Others are made of concrete. Some have been made of slate slabs, bolted together. There are baths made out of solid blocks of marble. One brought from Rome, and consequently a real "Roman bath," the writer saw the other day in a nobleman's mansion in the North of England. Fig. 533 is a sketch of this bath, which is hewn out of a solid block of grey granite.

FIG. 533.

The sizes are as follows: Length, 8 ft. 6 in. outside, and 6 ft. 6 in. inside at top, and 5 ft. 6 in. at bottom; the width being 3 ft. and 2 ft. 3 in. at top and bottom respectively; the inside depth being 1 ft. 9 in. The thickness of the sides, ends, and bottom is 6 in. The feet are of bronze and are modern make. The age of the bath must be very great, as the surface of the granite, both inside and outside, is very much pitted. It is not in use, but placed in a gallery amongst some very old marble statuary and other relics of a bygone age.

Waste-pipes will now claim our attention. Baths should be made to empty quickly, especially when required to be used two or three times in quick succession. Beyond this, the water, when so discharged, has a good scouring force which tends to keep the drains clean. Numbers of cases are found where only ¾ in. or 1 in. waste-pipes are used. These not only allow the water to dribble away very slowly but are constantly being choked with small pieces of soap, fluff off washing flannels, fragments of sponge, and other small matters round which soap curds cling, and eventually entirely block the pipe. When larger pipes are used and they are properly fixed the stoppages rarely occur. The writer had a case where a bath took 43 minutes to empty. On taking up the flooring of the room it was found that the horizontal part of the pipe leading to an open head outside was laid in notches cut in the joists. Between the joists the pipe had bagged down in two places. The bags being filled with water and the parts over the joists with air rendered the pipe "air-bound." After straightening the pipe and passing a cane through, the bath emptied in 15 minutes. It is very important that any horizontal waste-pipe should be fixed with a gradual and regular fall to its outlet, or junction with a vertical pipe, not only to prevent the above evil, but also any accumulation of matter inside to form a blockage. At a future time we shall have something to say on hydraulics and will work out examples of what quantity of water different sized waste-pipes will discharge. For our present purpose it will be sufficient to say that baths should never have them less than 2 in. in diameter. Under favourable conditions a 1½ in. pipe will give good results but not nearly equal to 2 in. In some cases 3 in. pipes have been used, but these are generally in public institutions.

Not only should the waste-pipe be of a good size but also the discharging plug or valve and the trap. The latter should not be larger than the pipe. In practice it is found that a round pipe-trap (as Fig. 275 in an earlier lecture) of the same size as the waste-pipe answers its purpose perfectly. When larger ones, or those similar to Fig. 263 are used, they invariably choke up by an accumulation of slimy matter inside, as was described in the text accompanying the illustrations above referred to. The connection to the bath should also be of a good size and not less than that of the pipe. One often runs against an iron bath with a 1 in. waste-union attached to it and a 2 in. lead pipe soldered onto the union. When a discharging apparatus is fixed the brass grated connection is frequently found to have a water-way much less than the waste-pipe attached to it. Although the grating should have a good way through, it does not follow that the holes should be so large that pieces of soap, &c., could pass through. The connection should be enlarged and more openings made rather than the size of the holes increased. This holds, too, in the case of manufactured sheet metal baths, either of copper, tin or zinc. A great many of these fittings have a small number of tiny holes partially filled with the enamelling material, the aggregate size of openings not nearly approaching that of the waste-pipe. When writing specifications for improving sanitary fittings "take out bath, send to the works, enlarge waste and overflow holes, fix new well and dish, larger underwaste and overflow pipes, re-enamel and refix bath with quick discharging waste-valve" is a stereotyped phrase frequently used when the fitting is made of good material and worth doing. In noblemen's mansions good old copper baths are frequently condemned and

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others of lighter and flimsier construction substituted when it would have been better to have altered and refixed the old ones. The reasons for having large waste openings and pipes apply also to the overflows with the additional one, that if the hot and cold water service taps are left running a serious injury to the house and furniture might occur if an overflow of water were to take place.

The treatment of waste-pipes is varied according to the fancies of the people who fix them or design their arrangement. Some will have them fixed indoors, others outdoors. Some plumbers will continue them to empty into an interceptor trap in the basement, and others prefer them to empty into an open hopper head

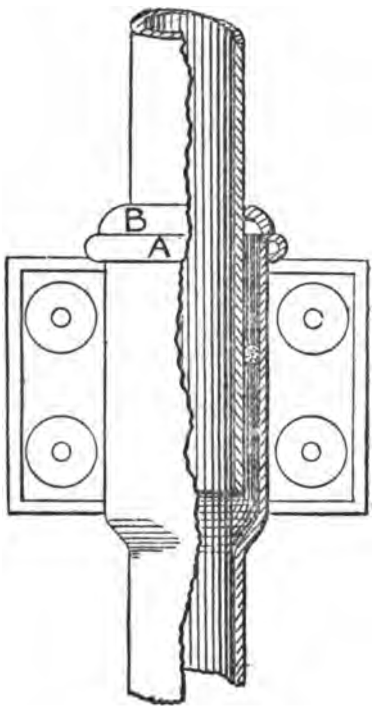

FIG. 534.

outside the house and thence to the interceptor trap. We will deal with some of the arguments applying to each method. In the first place the materials used are lead, wrought iron, copper, and cast-iron. When lead pipe is used and the joints are made in the ordinary way, that is, by wiping them, it will sooner or later break by the alternate expansions and contractions caused by hot water passing through. This points to lead as being an unsuitable material for hot water waste-pipes when fixed inside the house. When to be fixed outside the lead pipes can have expansion joints made on them. Fig. 534 is a sketch, half in elevation and half in section, showing a very good one. The pipes are generally made in 12 ft. lengths and are cut into two. Sockets are made on one end of each piece by means of a special made mandril, and a bead is sometimes turned as shown at A, but this is not necessary. Very strong ears are soldered

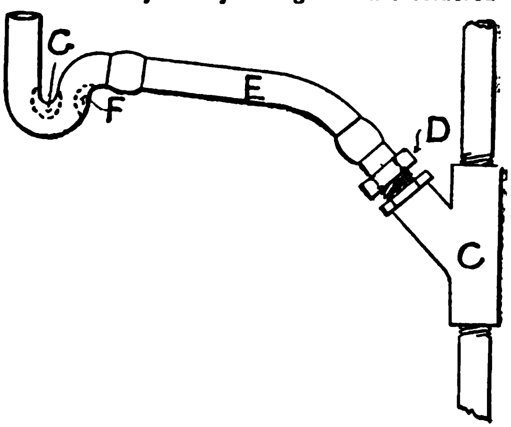

FIG. 535.

onto the back of the socket for fixing to the wall by means of nails or screws. On the plain end of one pipe an indiarubber ring is stretched and then slipped into the socket of the other, as shown in the sketch. The plain end of the pipe should not reach to the bottom of the socket, otherwise there would be no room for expansion. A small bossed lead cap is slipped on at B for keeping out dust, and also to add to the appearance of the pipe. After several years of experience with pipes so fixed, and never having seen a breakdown with them, the writer can speak well of this method. Several high stacks of pipes, with the joints as described, have been tested by filling with water, and found to be satisfactory, but it is doubtful if it would be safe to fix them indoors. On account of its smoothness inside, ease of application and making branch joints, lead must be accepted as being the best material to use under the above conditions.

When the waste pipe must of necessity be fixed inside the house, it is then best to use galvanised wrought iron pipe with screwed joints. The trouble in this matter is to make the branch connections, which must be of lead when the bath trap is made of that material. The best way of doing this is shown by Fig. 535, in which C is a Y-shaped wrought iron socket, D is a brass union screwed into the branch and soldered to the lead waste-pipe E. The Y-branch sockets are much better than those made at right angles and known as T-pieces, for reasons that were given in an earlier lecture. In addition to this the connection as shown in the figure will allow for a slight motion of the pipe by expansion and the contrary force. When rigidly fixed a branch frequently breaks near the joint to the vertical pipe. In some cases

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the traps come to grief by first becoming distorted, as shown by dotted lines in the figure, and then breaking at F and G. The writer has seen a number of traps broken in this way. In a few cases he has had the branch pipes fixed as shown by sketch plan, Fig. 536, instead of as shown by the dotted lines. In the latter case the expansion of the material is expended at the ends, but as shown by firm lines, the force is partially relieved at the bend. Even this will become crippled and eventually break in the throat at H where excessively hot water is used and the fixings are too rigid. In such

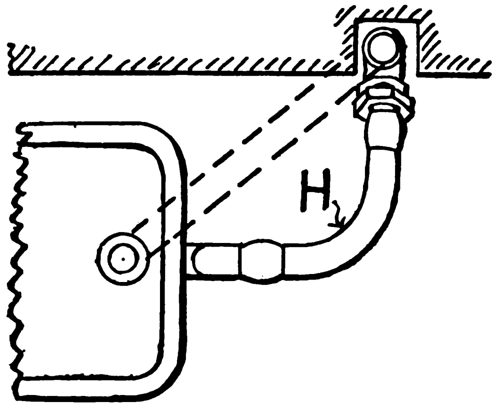

FIG. 536.

cases an expansion joint could be used, but this is not advised, as the packing material will eventually decay and the joint will leak. Being situated beneath the flooring there would be some difficulty in making any repairs to such a joint. The same difficulty is experienced when a lead pipe breaks, but by proper arrangement this would not occur. When the cause is pointed out it only remains to take precautions for preventing any evil consequences, and by a little careful thought this can always be done by the plumber to suit the work he may have in hand.

When copper waste pipes are used and fixed inside the house they should be put together by screwing. Sometimes they are joined with solder, similar to lead pipes, but it is not always safe to trust to such joints. When the pipe is fixed outside the house slip joints can be used.

When cast iron waste-pipes are used they should not be joined together by means of metallic lead or lead cement. In this case, too, expansion has such an influence on the metal (iron) that a kind of telescopic movement takes place at the joints, which eventually works the material out of the sockets. This is not of serious importance when outside, but it is different when inside the house. Iron waste-pipes get very foul, and the contained air is not suitable for breathing, hence the importance of having tight joints when any escaping air would be injurious. There are numbers of patented joints for iron pipes which are used principally for hot water heating purposes. Fig. 537, is a sketch of such a joint. These fittings are found to answer very well indeed for hot water waste-pipes. At every joint a slight movement can take place without breaking. When these pipes are used they should be tested after fixing by filling them with water. The joint may appear to some readers as wrong end uppermost, but they are best fixed so as any leakage in the joint would soon show itself and lead to attention being given to it. The makers of these joints supply also any special fittings and junctions, to which can be attached short pieces of branch lead pipes from bath traps.

When waste-pipes are fixed inside the house there is very little difference of opinion amongst experts as to the advisability of making all the joints both water and air-tight. There are still a few people left who think that a bath-waste made of light rain-water pipe with unmade joints can be fixed inside the house with safety. At a seaside hotel the writer found such a pipe with open hopper heads at the various floors, into which the baths and sinks emptied. All these latter fittings had traps to them. For the sake of the student it may be added that under the circumstances the traps were useless. Older men would know this without any prompting. Even among professional men there is a difference of opinion as to fixing pipes outside with open heads for receiving branches from sinks and other fittings. Fig. 538 is a sketch elevation of a case of this kind taken from a west end of London block of mansions, and may be accepted as a fair example of numerous others. On each floor,

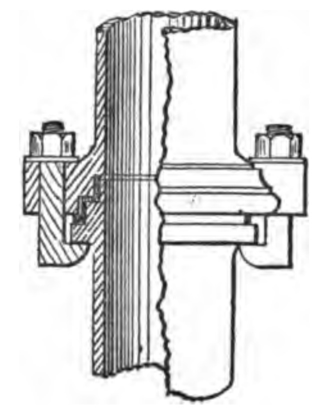

FIG. 537.

the building being six stories in height, is a bath, a sink and a cistern, all in the same room. The sinks are used for receiving bedroom slops, and toilet-bottles and jugs are filled at the taps. The sinks and traps are all trapped, as shown in the figure. The cistern overflow-pipes are not trapped, so that foul smells can pass through and contaminate the water. The hopper heads are level with and about 6 ft. away from bedroom windows. The problem

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may be accepted as one showing how to do work in an unsanitary manner. In opposition to those who adopt this style of arranging work, the writer cannot agree to the principle. In numbers of cases plumbers have been sent for to cover the hopper heads because of the foul smells escaping from them and passing into open windows. And if the smells are objectionable, what is to be said of other matters which have no odour? If a bather has an eruption or skin disease, or a child recovering from scarlet fever has a bath and the waste water passes down the outside pipe, it is only reasonable to suppose the disease germs can be distributed with the smells. The baths and sinks are trapped to prevent foul air passing through the waste-pipes into the house; but what avail is this if an open window allows its entry? Windows are opened for ventilation, that is, for the admission of fresh air and not that which is contaminated. On opening a window the air current is nearly always inward and very rarely the reverse. The overflow

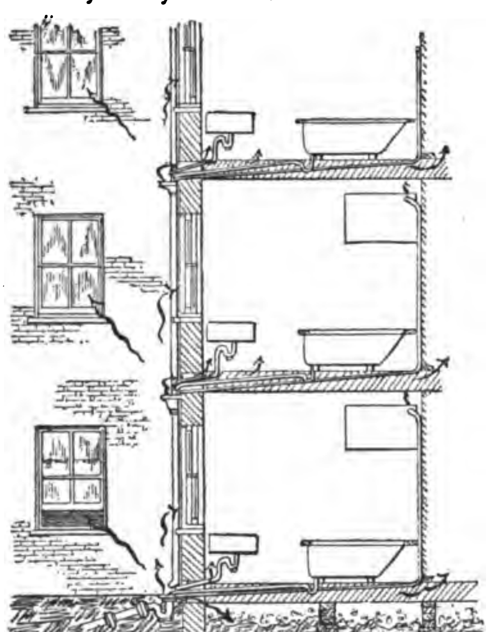

FIG. 538.

from the cistern has been referred to. In our problem we have other evils than those mentioned. Near each of the hopper heads is a grating and hole through the wall for ventilating the space between the floor and ceiling. The one at ground floor level is close to the gully-trap, so that not only foul air, but the dirty water that rebounds off the grating of the trap gets beneath the wooden floor on the other side of the wall. In each case foul instead of pure air passes into the dwelling. The main stack of pipe discharging over the gully-trap is another blot. The water that comes down the pipe splashes over the area pavement, and what does not leak through the joints of the stone slabs slowly runs back into the trap, leaving ill-smelling soap curds behind. A cock and hose pipe are provided for frequently washing down the pavement, but shortly after doing this the whole is as bad as before. At one visit to this place it was found that a few pieces of paper had either drifted or floated onto the gully-trap grating, thus completely choking it, so that what may be called sewage lay to a depth of some few inches all over the pavement. The examination was not made, but there is little room for doubting that some of this water had run through the floor-grating above referred to. In the winter time, too, what a deplorable sight is presented by the appearance of a house covered with sheets of ice and icicles hanging from the hopper heads, the whole being added to each time any water is discharged from any of the fittings. By this serious harm is done to the house walls. The mortar comes out of the joints in the brickwork on the outside, the decorations are destroyed on the inside, and this is in addition to the evils of damp walls. And yet this system is practised under the title of sanitary engineering. The writer has known cases where work has been arranged in this way, and yet objections were taken to using the rain-water pipes as sink and bath wastes. One principle is as bad as the other.

Probably a time will come when fixed rules will be issued for the treatment of the matter under discussion. The public are continually complaining, and rightly so, of the great differences of opinion amongst plumbers and so-called sanitary experts. As an example of this, a landlord has a house put into a sanitary condition (?) by some one who advocates waste-pipes emptying into open hopper heads, as above described. A would-be tenant sends his own plumber, or professional man, to report on the salubriousness of the house, who at once condemns it owing to the arrangement as carried out. In other cases, the reverse is done; good main stacks of waste pipes are taken down, and those with open hopper heads substituted. Amongst many cases of this kind that come to memory is one of two houses in the same street in an aristocratic part of London. In each house the main waste pipe from upstair fittings was fixed outside at the back. The pipes were made of 2 in. cast iron having ordinary slip joints. Both houses were alike, having been built by the same contractor. Two prospective tenants sent their respective sanitary engineers to examine the houses, and each one was condemned as being unsanitary owing to the waste pipes. The proposed remedies were in direct opposition to each other. One engineer insisted upon the insertion of hopper heads in the main stack at the necessary positions for the branches to empty into. The other engineer applied a smoke test, and, as a little escaped at some of

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the joints, insisted upon a new lead pipe with soldered joints, which was both water and air-tight, being fixed. Not wishing to lose two good offers for his houses the owner had the alterations made as required. Very probably at a future time, when there may be changes in the tenancies, the whole arrangement in each house will have to be again altered to suit the fads and fancies of some other tenants and their advisers. If we had a code of regulations to work to, this confusion of principles would be abandoned to the advantage of all, whether clients, sanitary engineers, or workmen.

As Fig. 538 clearly illustrates the principle of open heads we need not describe any other examples, but go on to alternative problems. But first we must go back on what has been said, and consider the proper position for the waste pipes. Undoubtedly outside the house would be the best, but for the fact that such pipes are frequently ice-bound during frosty weather. This dces not arise from the water discharged from baths or sinks, but from leaking taps. The writer does not remember a single instance of an ice blockage where it was not traced to a defective cock. A large body of water flowing through a pipe does not freeze, but a dribble will do so. Numbers of people will leave their draw-oft cocks slightly opened to allow of a dribble of water, to keep that in the service pipe moving, to prevent freezing. This may be effective in the service pipe because the whole body of water in it is kept in motion, but the same water trickling down a waste pipe will freeze. From this we glean that if all cocks are sound, and no waste practised, the pipes can be fixed outside the house. But, and it all turns on this, it is almost an impossibility to guarantee everything to be always as it should be.

Outside pipes can be encased and protected from freezing, but such fittings never add to the good appearance of a house. They also rot away in time. Numbers are found in dilapidated conditions, and the packing material in a state of decay. As these points are of considerable importance, and we cannot ignore them, it only remains for us to fall back on an inside position and fix the pipes where the frost will not act on what passes through them. By this, it must not be assumed that they should be fixed inside at all costs or that they should be situated near, or pass over rooms where a leakage would lead to a serious injury to anything in them. In such cases, rather run the risk of a blockage of ice and fix them outside. The baths, sinks, or whatever is connected to the waste-pipe should then have overflow-pipes attached to empty into the open air. These overflows, under certain conditions, would be rendered useless by being choked with ice, but with them the risk of injury by an overflow would be much reduced.

Where baths or sinks are fixed over each other, and it is objected to having too many pipes showing on the outside of the house, the vent-pipes are sometimes fixed inside. In addition to the unsightliness of a cluster of pipes fixed externally, it must be admitted that the mutilation of the walls by cutting holes for the several branches is very often a serious item. Not only with regard to the cost of cutting the holes and making them good after the pipes are fixed, but also bearing in mind that the several holes tend to weaken the walls. For these reasons there are many architects who will have all pipes fixed indoors. In some cases it is an economy to do so, and thus save the cost of scaffolding for the workmen's use, and which they should have when fixing pipes externally.

We will now dwell for a short time on the structural details of an outside waste-pipe, the vertical joints being made as shown by Fig. 534. The reader is referred to Fig. 539, in

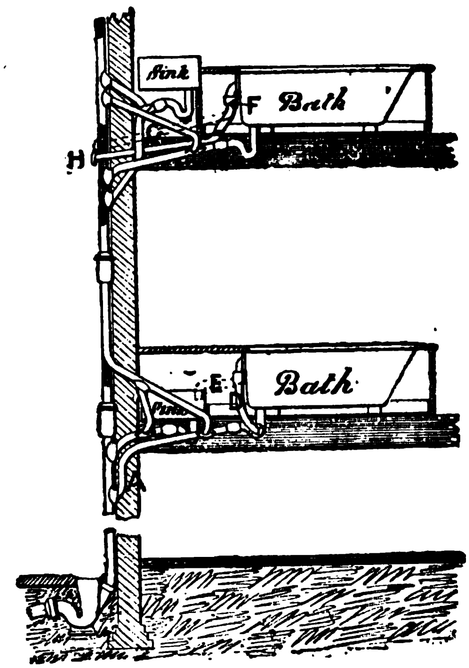

FIG. 539.

which is shown two important points often met with in practice. The usual method, when two or three fittings are close together, is to branch the various waste-pipes into one, fixed horizontally. This was illustrated some time ago (see Fig. 104). The usual result in such cases is the water emptied out of one fitting will flow back into one of the others. As a convenience for drawing water into a can a small drip sink is often fixed inside the bath enclosure, as shown in the lower half of the figure. If the sink waste was branched into that from the bath, when the latter was emptied

the water would rush up into the sink and probably fill it to overflowing. If the sink was level with the bath, as shown in the upper half of the figure, what was thrown down the sink would rush up into the bath. In each case the remedy is to branch the waste from each fitting into the vertical pipe. And in each case the branch from the low-level fitting should be joined so that the water could not possibly flow back as above described. Neither should the waste from upper floors flow back up the branches of anything on the floors below. In an earlier lecture on soil-pipes, see Figs. 286-7-8, it was stated that all branches should as nearly as possible approach bends in their construction, and the reasons why were given. These apply also in the case under consideration. The lower portion of Fig. 539 is taken from a mansion in Worcestershire. The walls were of stone, and to avoid disfiguring the building, chases were neatly cut behind the vertical pipes to hide the branches shown at A, in the figure.

Every branch waste pipe should be ventilated by means of a pipe as illustrated. A great many people consider the cost of this to be a waste of money, and this idea is not confined to laymen only. It is thought that a bath or flat-bottomed sink always retains sufficient water to afterwards slowly dribble into and recharge the trap when emptied, or partially so, by syphonage. This holds good in the case of single fittings, but when several are connected to a waste pipe which is common to them all, the use of one bath or a sink may empty the traps of the others. This subject was dealt with to a considerable extent in the lecture on soil pipe and trap ventilation. The reader should refer to what was said on that matter to be the better able to grasp the importance of applying the same rules to waste pipes. In Fig. 539 the trap vents are shown branched into a main stack in the upper half, and in the lower portion they are joined together before passing through the wall. Either way is found to answer fairly well in practice. In some cases the trap vents have been branched into the main waste-pipe one or two feet above the waste branches, but this is not at all a good method to adopt. When water is falling from upper floors the compressed air in the main waste will blow through the lower traps, owing to there being no relief or ventilation for its escape in the same way as when the vents are separate from the waste pipe.

In other cases, the branch trap vents have been carried through the walls and left with open ends. Although this may not be quite so objectionable as open hopper heads, it cannot be accepted as being so good as carrying the open ends of the pipes to some position above and clear of all windows and openings into the house.

The sizes of the waste pipes have been dealt with, but a few words on the sizes of the vent pipes may here be an advantage. Without repeating the details of the earlier lecture above referred to, on soil pipe and trap ventilation, it will be sufficient to say that in no case should such pipes be of a smaller bore than the waste pipes. At times it becomes necessary to increase their size, especially where they must be very long or have many bends in them. Many examples are continually coming under the writer's notice where ¾ in., 1 in. and 1¼ in. ventilation pipes are fitted to stacks and branches of 2 in. waste pipes. With scarcely any exception these small vents have proved failures, and the traps were partially emptied by syphonage. And what is the good of a trap if the water seal is broken? In some instances, with 2 in. wastes, 2½ in. and 3 in. main vents, with 2 in. branches to the various traps under fittings, have been found necessary for keeping the water seals intact.

It is found to be an advantage, in very long lengths of vertical waste pipes, to keep the main vents quite separate from those on the waste, and continue the top ends of each to the desired positions. Where the combined main waste and vent is not very long, the trap vents can be branched into that on the waste, but this connection must be made above the level of the highest branch from the sink, bath, or other fitting. Cowls on the top ends of such vents are worse than useless, in that they prevent air freely entering to fill the partial vacuum formed inside the pipes when water is falling down. For keeping out birds, or the materials for their nests, a large size domical grating is all that is necessary. The grating should be made of copper wire. When made of iron wire and galvanised they last but a very short time. Steam and watery vapour will soon destroy the latter.

Waste-pipes from baths and sinks, according to our English ideas, should not be in direct air communication with the soil drains, but should be made to empty *into* so-called "intercepting traps." I say into advisedly, and cannot bring myself to agree with the bad principle of such pipes emptying onto pavements, or over the gratings of gully-traps, which is as bad as the other, so often preached and practised. If the reader refers to the text accompanying Figs. 213, 214, and 257, he will find very good reasons for fixing the waste-pipes to the inlet arms of the intercepting traps, as shown by the latter figure. The trap shown at the foot of the waste-pipe, Fig. 539, is of this description.

Some engineers and plumbers fix intercepter traps with open channels. This arrangement is no better than fixing the pipes to empty over the gratings of the traps, owing to the splashing of dirty water over the surroundings and also because of the grating over the trap being frequently choked with leaves, pieces of paper, and other matters that are usually found to be drifting about near houses. In such cases the channels fill to overflowing, and the dirty water

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soaks into the house walls. This statement was made in print some years ago and resulted in correspondents sending letters and giving their experiences, which were very similar, and endorsing the present writer's views.

In some country towns and districts the sanitary authorities insist upon open channels for waste-pipes to empty into. Some years ago certain works had to be done under local bye-laws which stipulated that these open channels should be used, but, after pleading very hard, consent was given for gratings to be fixed over the channels which were at the ground level. Fig. 540 is a longitudinal sectional illustration of the arrangement. The trap has an opening at B, for passing rods through for clearing the drain when necessary.

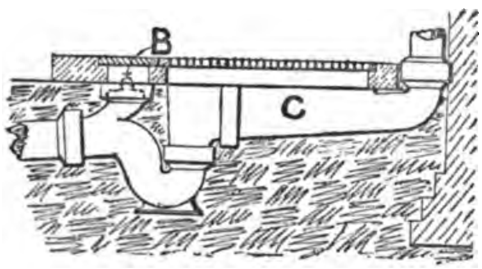

FIG. 540.

This opening has a stopper bedded down air-tight and a galvanised iron plate fixed over an aperture in the stone above, so that the whole is easily accessible without disturbing or breaking any part of the trap or drain. The channel, C, has a bend and socket at the highest end for connecting a vertical waste-pipe. Others have sockets at the ends for receiving horizontal waste-pipes. A York stone with a galvanised iron grating and the above named iron plate is bedded over the whole, as shown by the plan, Fig. 541. On removing the grating a brush can be used for cleaning the channel when dirty.

There are other especially designed traps in the market which have channels, or hopper heads, and cover gratings to them. One was

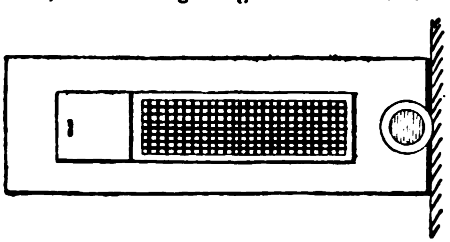

FIG. 541.

shown by Fig. 256, in a previous lecture. Most of the traps of this kind have been designed to meet certain bye-laws issued by sanitary authorities, and are used a great deal in places where it is the practice to omit all traps under sinks, baths, or wash-basins. The writer considers the whole arrangement to be unsanitary, and his reasons have been so often stated that it is unnecessary to repeat them. The question of having traps under lavatory and sink fittings will be dealt with at another time.

Overflows are our next consideration. These pipes should always be large, never less than 2 in. in diameter, as small sizes will seldom take away the water as fast as it can run into the bath. Various ways of treating them are shown at D, E, F and G, Fig. 539. D is branched into the trap under the bath. When so fixed, and the waste pipe, or trap, is choked, the overflow is useless. Neither is it a good plan to firmly fix this pipe. As it gets foul, it is an advantage to be able to take it down and wash the inside. Where a sink has been fixed under the enclosure, the bath overflow has sometimes been made to empty, as shown at E. The pipe can be taken down and washed clean, but when so fixed an overflow pipe should also be attached to the sink. Although the latter is intended only for catching drippings from the draw off cocks, dirty water is frequently thrown down and and the grating over the waste pipe choked with fluff and other matters which prevent the water running away. At F, the bath overflow is shown as emptying into the safe immediately over the waste pipe which empties into the open air. Objections have been taken to this, although it is thoroughly sanitary, a current of cold air can pass from the outside and through the two pipes. One client complained that when having a warm water bath she had a cold air bath at the same time. To cure this, the overflow was made to empty some little distance away from the open end of the safe waste pipe. Although done in this case it cannot be recommended for general adoption unless a sinking is made in the floor to form a kind of cesspool, as fixed at the ends of lead gutters on roofs, to prevent the water spreading all over the lead safe. Sometimes the overflow has to be fixed to empty into the open air, as shown by dotted lines at G. Some of the London water companies stipulate this to be done. The only objection is the one referred to last. In each of the latter cases the bath should be filled by cocks fixed to discharge over the top, so that the incoming water is visible, and there is then less liability of their being left open too long. The grating over the overflow should also be fixed a good distance above the bottom, so that when the bath has too much water in it the displacement caused by the user getting in will be less liable to bring the overflow into use. A bather should always have the bath filled to the proper depth, and if too full some of the water should be run off. Otherwise a nuisance will be caused outside below the point where the overflow discharges.

To prevent cold air entering as above described some plumbers, and it is the most common practice, will fix copper hinged flaps on

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the outer ends of the sae waste and overflow pipes. As several times these flaps have become so rigidly fixed as to become useless, thus leading to damage to the contents of houses, their use has been abandoned by some of our leading plumbers and copper capped, or hooded, ends substituted, as shown at H, Fig. 539. Although preventing a decided in-blow, when the wind is in the right direction, air can pass through these hoods sufficiently to become objectionable. As no bad air can pass through these pipes, excepting as it becomes fouled from the slimy lining when they are dirty, they cannot be called unsanitary and, as for the cold air passing through, that can be stopped by hanging a towel over the overflow grating in the bath during the time it is being used.

We may here leave our subject for a short time to say that all baths should have a "safe," or "save all," beneath them. In some cases the floor can be dished to fall to outlets and made of impervious material. When fixed upstairs on wooden floors the latter should be laid to a fall and covered with lead, with the sides standing up 3 or 4 inches. Very rarely, indeed, are the wooden floors laid properly. Usually we find them falling the wrong way and the waste pipes fixed at those ends of the safes which are the highest. In such cases any dirty water getting into them cannot run out but lies in pools on the lowest ends and gives off bad odours. Sheet lead is the best material to use, of the substance known as 4 or 5 lbs. is quite thick enough. As an economy small safes, under the cocks, are often fixed, but as the safes are intended to catch any leakage or overflow from the baths, they should cover the whole of the spaces, and a few inches beyond, on which the baths stand.

To return to our subject, a great many are fixed with combined waste and overflow arrangements. Fig. 542 shows such a fitting. The

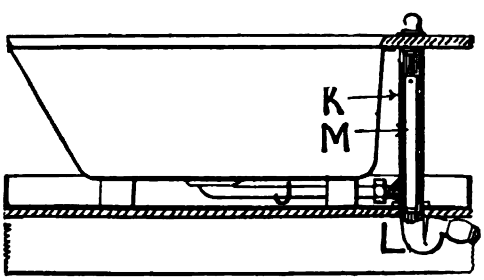

FIG. 542.

underwaste, J, is connected to a pipe, K, the top end of which is open and the bottom end connected to the trap L.

An inner pipe, M, acts as a waste plug, and has the bottom end fitted to the outlet of the larger pipe, the top end being open and cut down to the level it is intended for the bath to fill. As the latter is filled the water rises in the annular space between the two pipes until it reaches the top of the inner one when it overflows and runs away down the waste pipe. There is little room for doubting that this was a Scotchman's invention, as in travelling about the writer finds them made of lead and fixed by plumbers in nearly all Scotch towns. It has also occurred to him that the same principle was introduced into American practice by the same class of men. This is fortified by looking over lists of plumbers in American towns and noting the number of names which are similar to those met with amongst our northern confrères, and who were doubtless amongst the earlier settlers. Coming nearer home the writer, in looking back over an experience in London of 35 years, does not remember ever seeing such a fitting until it was made by hand by Scotch plumbers who were working in the same shop as himself. This was about 26 or 28 years ago, but since then nearly all bath makers have adopted the principle, and the fittings are now made in cast iron, galvanised iron, copper

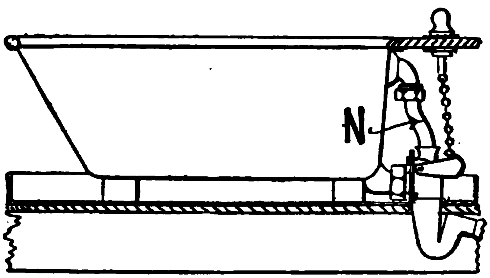

Fig. 543.

and lead. In 1881 or 1882 a writer in a New York technical journal condemned the principle as being bad, owing to the foul condition the waste and overflow pipes became inside by usage. Since then some of our English authorities have taken up the same line. The writer has had to exchange such fittings because of complaints of bad odours escaping from them. Although still practised in London there is not the least doubt they will eventually be superseded by something better.

Another arrangement is shown by Fig. 543. The discharging valve is very large and made to open so that the waste pipe, not less than 2 in. diameter, is filled full bore and empties the bath very quickly. In this case the overflow pipe, N, is made to be easily taken down, without removing any part of the bath or the enclosure, and scalded or otherwise cleansed. It is very probable that this will eventually be improved upon and provision made for cleansing the overflow arm of the bath. This may appear to be a trivial detail, but as the filth that accumulates even in this short pipe is objectionable, means should be provided for removing it. Whenever the overflow is connected to the waste valve unpleasant loud gurgling noises are made when the bath is being emptied.

Fig. 544 is an illustration of one of several fitted up by the writer a great many years ago,

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and which then was considered to be a very good system to adopt. A large stop cock, with wrought iron socket key and spindle having a brass lever and knob, to be turned outside the enclosure, was fixed for emptying the bath. At the present day this kind of cock is being superseded by other fittings which are not so difficult to turn and are less liable to leak. It will be noticed that the supply and waste cocks are soldered to the various pipes, and at one time this was the usual practice. When the bath or cocks required repairing or renewing the joints had to be unsoldered and afterwards re-made. The overflow was by means of the pipe O in the figure. A small hole at P was made to prevent a syphonic action setting up and emptying the bath whenever it overflowed sufficiently to fill the pipe. The hot and cold water supply cocks were connected to the waste pipe, so that if they and the waste cock were left open the water ran to waste. In one example that comes to memory the cisterns were emptied through this occurring without being noticed. The principle is bad from

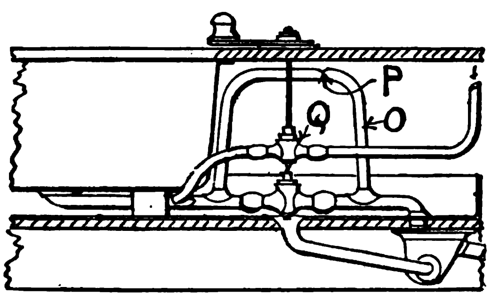

FIG. 544.

another point of view, the underwaste is generally very foul inside from the soapy matter, &c., left in it when the bath is emptied, and the incoming water will wash the filth back. The supply cocks shown at Q were of the ordinary description. Such cocks are now going out of use as they have so many objectionable points in connection with them. They last but a very short time without leaking, and at times are very difficult to turn. The hot water cock will sometimes become so rigid that the brass lever and the knob are broken in the efforts to turn it. Fig 544 is here given as a peg on which to hang several defective arrangements in bath fitting and to illustrate how not to do them.

We can now pass onto supply cocks or valves for baths and their fitting up. An objectionable method is described above. An improvement on that is shown by Fig. 545. The supply cocks, only one of which is shown, the other being on the opposite side of the bath, is of the screwdown kind, having unions at the ends for easy removal for any purpose, and also for preventing injury when the plumber is making the joints. The connection is made at the sides, a few inches above the bottom. When so connected a small quantity of cold water can be run into the bath, and when the end of the inlet pipe is covered the hot water can be turned on. This will prevent the room being filled with steam, of which complaints are frequently made. Steam is objectionable because of the damp condition into which the contents of the

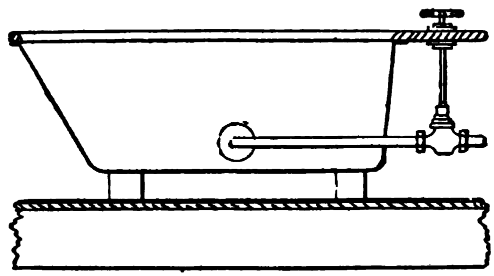

FIG. 545.

room are rendered, and when it is also improperly used as a wardrobe or linen room the dampness is highly objectionable. At one of the works the writer has in hand, at an Earl's mansion, the walls of the principal bath and dressing-room are hung with several old curios, including some ancient steel armour. Steam amongst these would be very injurious.

Another way of connecting the supplies to a bath is shown by a plan, FIG. 546. The two cocks are connected to a breeches piece, R, which in turn is joined onto the bath. This is sometimes claimed as an improvement on the last one described, but when the hot and cold water are supplied from tanks at unequal levels, that from the highest tank will have sufficient pressure to keep the other from flowing into the bath, thus showing that independent connections are the best under the conditions

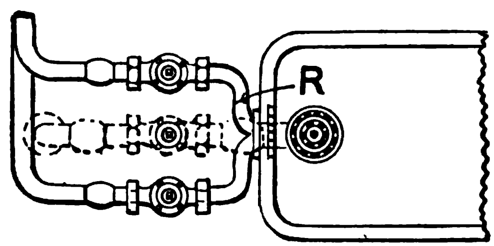

FIG. 546.

named. The centre cock is for the waste and is separate from the others. There are a few other details on this matter which we need not now dwell upon as they were described in "Plumbing Practice."

There is one, however, which a recent experience has reminded me of, and which is frequently found in practice. That is the evils of fixing the supply cocks at the head of the bath, more especially when they discharge over the top. When it is explained that a leaking

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cock under these conditions allows the hot water to drip on to the face of the bather no further comment is necessary.

Another objection is that hot water dripping from such cocks, especially when supplied through rusty iron pipes, will leave brown stains down the sloping head of the bath. When fixed over the toe end, and the nozzles are a fairly good length, the water drips clear and the stains are then not so objectionable. Sometimes they are caused by the tan from the leather washers used in the valves. On this head it may be said that sometimes valves which had indiarubber or fibre washers, when new, have been repaired with leathers. Such material may be good for cold water, but for hot water it is far from being so. With boiling water the leather is converted into glue, and with moderately hot, the leather is rendered very hard and brittle, so that it lasts but a very short time.

Again, referring to Figs. 542 and 544, it will be noticed that the waste-pipes are connected to the baths near the centres. This gives in each case something like 2 ft. 6 in. or 2 ft. 9 in. of horizontal waste-pipe which gets foul inside and gives off musty odours, or something worse when the pipe is bagged in any part and retains soap curds, which eventually turn black and decompose. Although this is the usual practice, it is far from being a good one. The pipe

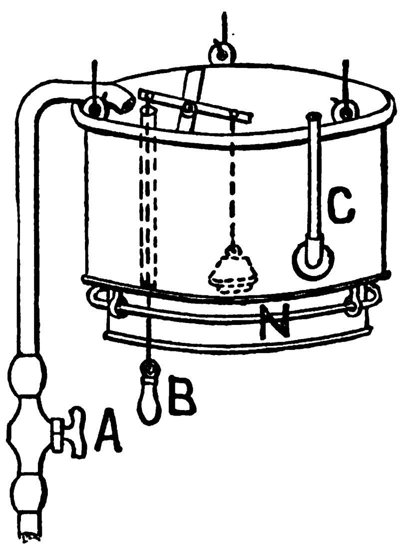

FIG. 547.

cannot be cleansed by means of a brush or other aid, and simply passing water through does not improve matters. The perforations come in an uncomfortab e position for the bather to stand or sit upon, and, in the case of copper, or other sheet-metal baths, the cradling cannot be properly done, so that the bottom is unsupported and becomes so irregular that the water will not entirely run away. The connection near the toe end, as shown by Fig. 546, is a great improvement, but can only be applied to fireclay and similar baths. The connection is made of brass, with a trumpet mouthed inlet, over which is placed a porcelain grating which can easily be lifted off for cleaning. For copper and similar baths the connection is best made as shown at Fig. 543. Instead of holes, slots are cut in the metal to form a grating for preventing pieces of soap or other matters choking the waste-pipe. By this method all the above objectionable details are avoided, and, in addition, when the water has nearly all run away, air is drawn in through the upper portions of the slots, with the result that when the trap is not properly ventilated, there is a lesser syphonic action set up. This is also found to be the case with some of the modern made wash-basins which have similar connections.

We will now refer to shower baths. These are made in a variety of forms, but very few are really comfortable to use. One great objection in those frequently met with is the size of the holes. When made too large the water passes through in such great streams as to be more like a deluge than a shower beating on the head and shoulders of the user. The smaller the holes the finer the water spray and the greater the pleasure in usage. Another objectionable feature is the length of time it takes to thoroughly exhaust all the water. This will hang up in the perforations, being held there by capillarity, for hours, and at frequent intervals one or two drops will fall into the plunge bath below, when so fixed, with a sound which is very irritating to nervous people. Clients have frequently complained of these disagreeable noises occurring during the night time when the baths have been fixed near the bedrooms. Fig. 547, is a view of a very common shower which is usually suspended from the ceiling. The water is turned on to fill the shower by the cock A and by pulling the handle B, the contents are emptied on to the user. There are no means of knowing when sufficient has run into the chamber to fill it. The person has either to trust to guess work, use steps for peeping over the top, or allow it to fill to overflowing, all of which are unsatisfactory. In a few cases gauge glasses, as shown at C, have been fixed for seeing the depth of water, but where one shower is found to have this, hundreds are without it. Sometimes a ball valve is fixed on the service-pipe, in which case the shower is always filled ready for use. Shower baths, like a great many other fittings in plumbers' work, are frequently left unused for several weeks together, with the result that they get out of order. The various working parts become rigid, or the leathers and rubbers "grow" to the valve seatings and are torn when opened. Hence such fittings are found to be n a chronic state of being out of repair. When

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constructed as shown by Fig. 547, they are generally used for cold water only. Although a few are fitted with hot water supply attachments it is dangerous to use them, as there is some little risk of the bather being scalded. A thermometer can be used for testing the heat of the water, but the trouble of doing this is a great objection, and the chamber may have to be emptied and refilled several times before the contents are found to be of the desired temperature. Even when a thermometer is attached and forms part of the chamber the correct heat of the water may not be recorded, as the hot and cold are not thoroughly mixed. The commoner baths are made of sheet zinc or tinned iron. Neither of these materials is found to be entirely satisfactory owing to the corrosion that takes place in the metals, resulting in the perforations becoming either choked up entirely or very much enlarged and distorted out of shape. Sheet copper is much better for shower baths, more especially for the perforated spreader, as this metal resists any corrosive action of the water much better than the others.

There are several varieties of shower baths, and a very long lecture could be devoted to them: We, however, need not dwell upon such fittings to a very great extent. A very simple and good one is shown by Fig. 548. The whole is made of copper and is nickel-plated. D is the shower or spreader supported on the 1 in. pipe E, which is fixed to the end wall by means of the flanged sockets F F. G is a cock with hollow lever having a spreader at the end. On pulling down the lever, as shown in the figure, the water escapes and plays upon the hips of the bather. This cock is useful for emptying the pipe, which, to a certain extent, mitigates the nuisance of the water dripping from the shower after being used as referred to when dealing with Fig. 547. When the shower is to be used the cock lever is turned upwards. H is a chamber in which the hot and cold water mingle, the temperature being shown by the thermometer, J. The waters are admitted through the breeches piece, K, on turning the cocks, L L, the knobs of which are engraved "Hot" and "Cold" respectively. The whole was designed for a medical gentleman's own use. In the first instance a cock was to have been fixed at M to regulate the quantity escaping at the rose, D, but on further thoughts this was abandoned, for the reason that if the water did not escape freely at the rose the cold would have forced its way into the hot water pipes, owing to the two cisterns not being on the same level.

The floor of the room was entirely covered with lead and the walls with glazed tiles to prevent any injury to rooms beneath from the water that rebounded off the head and shoulders of the bather beyond the plunge bath, passing through the floor. In some instances brass hoops with rings and curtains are fixed to shower baths, but in this particular case the client would not have anything of the kind. As these curtains are sometimes wet and cold they "give one the cold shivers" when getting inside. The ring shown at N, Fig. 547, is for suspending a curtain when desired. In continuation of this, it may be said that such curtains are always a nuisance. When made of vulcanised indiarubber, or so-called water-proof cloth, in which this material is a constituent, the smells are a common source of complaint, and after being in use for some time they become harsh and brittle. Plain linen, or cotton, curtains when used should be thoroughly dried each time, otherwise they become mouldy and rotten, and give off unpleasant, musty odours.

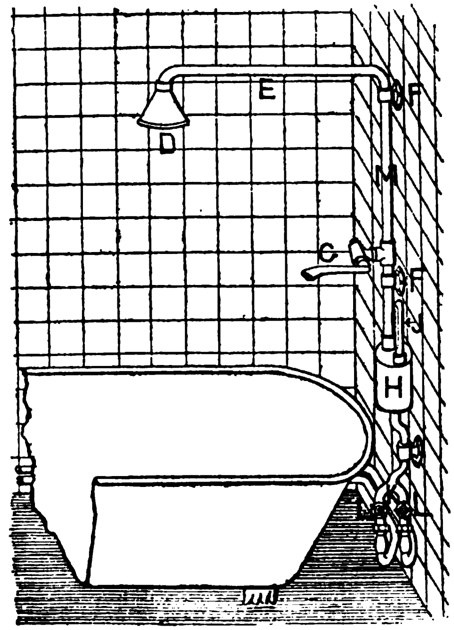

FIG. 548.

During these last few years, ordinary shower baths have been used less than formerly, especially since the introduction of the so-called "Needle" or "Combination" baths. We will now refer to these fittings.

The luxury of a needle bath has often to be foregone on account of the cost. This applies especially to those which were first introduced. Some of modern make are much more economical in their construction, but in many cases the fitting up brings the cost to that of the others mentioned. Fig. 549 is an illustration of an old pattern needle in conjunction with a plunge bath, which was, and is, liked by some people. The waters—hot and cold—are turned on either together or separately, as may be desired. It will be noticed that separate cocks are fixed for supplying the various parts, and each cock has an engraved face plate, or an engraved knob, to distinguish its purpose. Some baths are more

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elaborate and have fittings for sitz, or use in a sitting position and also for medical purposes. For ordinary use these extras should never be fixed. In practice, the arrangements are found to be complicated and confusing, and out of the

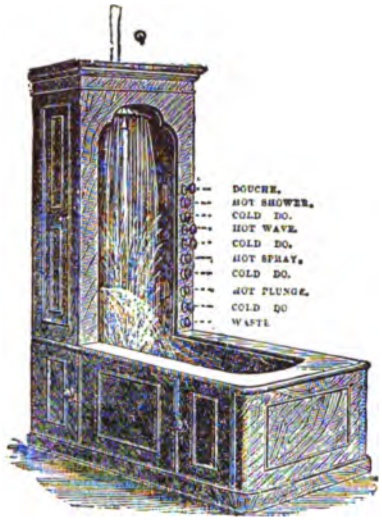

FIG. 549.

multitude of cocks and valves one or more is generally out of repair. This is especially so with those that are not much used, owing to the metals and washers sticking together and being injured when moved or opened.

Another bath with a less complication of valves is shown by Fig. 550. In this case there

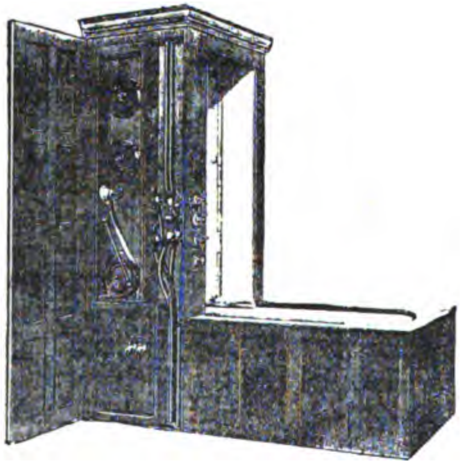

FIG. 550.

are only two, one for cold and one for hot water. By turning the centre handle so that the dial points in the proper direction the water is directed to the shower, spray, or plunge, as may be desired. Fig. 551 is a front view of the combination of valves, which is drawn to better illustrate the action. In Fig. 549, the rows of holes in the needle, or spray, are made horizontally, but in Fig. 550 they are vertical or over each other.

The remarks made on the materials for shower baths apply also to these latter. Zinc, being the cheaper metal, is frequently used where economy has to be practised; but it is a false economy, especially where the water used has a corrosive action and results in the filling up or distortion, as the case may be, of the per-

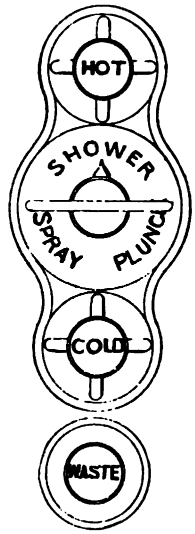

FIG. 551.

forations. Neither have these combination baths any fitting or appliance to denote the heat of the water, so that here, also, the bather should not get in until he has felt the temperature with his hands, and thus avoid the risk of being scalded. Reference has been made to the water from showers dripping for some considerable time after being used. With those fixed in conjunction with plunge and needle baths it has sometimes been found an advantage to have a small air or vent pipe, as shown at Q, Fig. 549. This will help the shower to empty more quickly and thus shorten the period of time during which the after-drip continues.

A sitz, or bath to sit in, is liked by some people. Some are fitted up with shower and spray similar to the others described. Fig. 552 is an illustration of such a bath. In some cases the curtain is omitted and the door made to fit, to prevent the water splashing outside. When so made it is an advantage to insert a square of glass or have a glass panel in the door, and have the cocks arranged so as to be accessible on the inside for the bather to have easy command over them without opening the enclosure.

Fig. 550, which is copied from a manufacturer's catalogue, shows a small sink with taps

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for drawing hot and cold water into cans or toilet jugs, and in the same enclosure a small hydrant valve and hose for use in case of fire. When so fitted, care should be taken in the arrangement of the waste-pipe from the sink. If improperly connected to that from the bath there is danger of an overflow when the latter

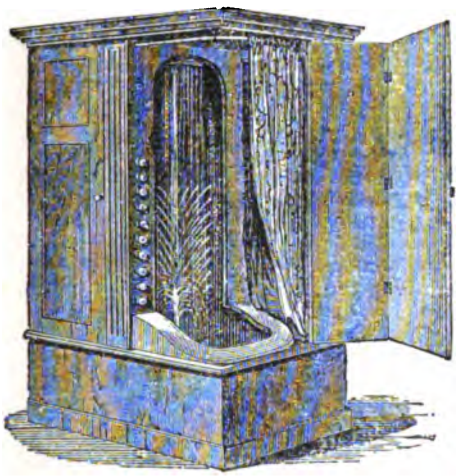

FIG. 552.

is emptied. To avoid this the sink waste should be joined to the other at a lower level, so that the waste water from the bath would have to rise a considerable distance before reaching the sink. The trap ventilation should also have special attention, as was explained when describing Fig. 539.

A modern needle and shower is shown by Fig. 553. This consists of copper tubes, either polished or nickel-plated, arranged as shown. The cocks, with breeches piece, mingling chamber and thermometer are all similar to those shown by Fig. 548, with the further advantage that the bather can use the cocks either from the outside or inside. The latter is found to be convenient after the body has been shampooed and when being rinsed it is desired to have the temperature of the water gradually reduced, which is done by partially closing the hot and further opening the cold valve. An attendant usually does this, but the bather can help himself when assistance is not available. The cost of this skeleton bath is much less than either of those shown by Figs. 549 and 550, but in fixing it due regard must be taken of the surroundings so as to protect them from injury by water. Where the floors are so constructed that they can be made water-proof by means of cement or asphalt, or covered with tiles, either process is good, the combined cost will sometimes nearly approach that of the self-contained bath and fittings. Where the room-floor is made of wood it can be covered with sheet lead, but this covering must extend some considerable distance beyond the bath and be turned up a few inches all round the edges. In any case the floor has to be laid to fall to some given point where a grating, trap, and a waste-pipe is fixed, to convey the waste water away to an interceptor or gulley trap outside the house. A piece of cork is very comfortable to stand upon when using the bath, and a blanket to step upon afterwards. This will prevent the feet being chilled by contact with the cold floor, and also minimise the risk of slipping.

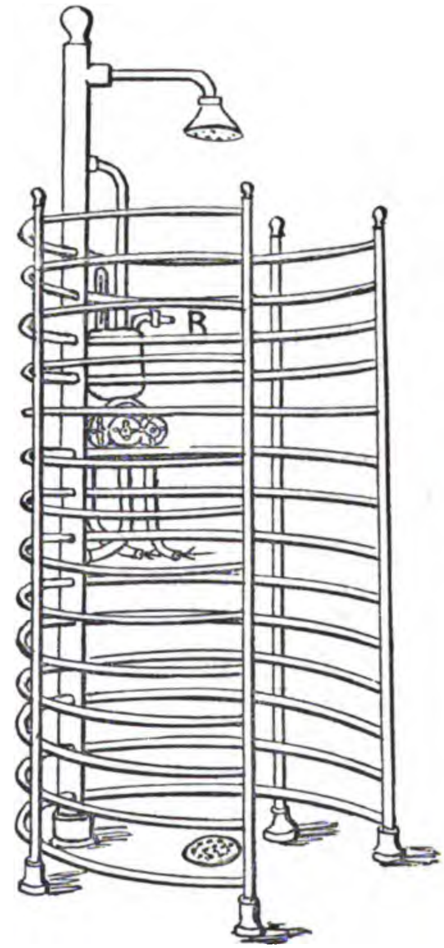

FIG. 553.

In addition to the needle and shower other attachments can be fixed for hip or spine, sitz, douche, or spray. A union fixed at R, Fig. 553, and a short piece of hose-pipe with a connection on its end to which can be screwed the necessary nozzles for the above is a simple way of providing for such contrivances. But to use them properly it is necessary to have an attendant. In private baths such fittings are rigidly fixed, especially where the water supply has a great head. The explanation for this is,

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assuming the bather is using a douche on various parts of the body, the issuing jet of water presses against the user nearly equal to a solid rod of some hard material. If the douche is on the end of a hose-pipe and the direction of the jet is turned slightly aside the water would miss the body and strike upon anything several feet distant, possibly doing a considerable amount of injury. This would be less liable to occur if an attendant were using it; but when rigidly fixed care would be taken to have the apparatus so that no injury could take place, or in other words, the baths shown by Figs. 549 and 550, or screens or hoods, would be used instead of Fig. 553. In elaborately fitted bath-rooms where floor, walls, and ceiling are all impervious to water the above remarks do not apply. Very few of these rooms are provided in mansions or private houses, although in a few cases they have been fitted up for medical purposes.

In some hospitals, where nervous ailments are especially attended to, very elaborate bathing arrangements are provided. Fig. 554 is a sketch of such a bath-room showing a few of the provisions, but not the supply-cocks and thermometers. In designing such a place a great many points have to be considered and the various fittings placed especially to suit any and all cases. Some of these points are as follows:—Helpless patients have to be carried to the room and supported when bathing, and as this applies to many cases, each requiring a different treatment, it follows that many different kinds of bath must be fixed in positions to suit each and all requirements. As the baths are used medicinally the patients must at times be so placed that the medical

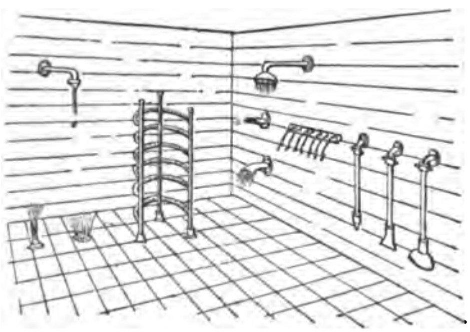

FIG. 554.

man can carefully watch the result, and at the same time not to become so wetted as to hinder him from attending his other duties without first changing his clothes. One patient may require to be deluged with water and another one have only a fine spray. One may be ordered to have a bath generally and another to have only a local application; one to be treated quickly and another to have a long continuous application. Some of the fittings must be arranged so that a special application can be applied to a patient in any position. As temperature is an important factor in the question, it follows that each and all of the various baths should be fitted with thermometers. These should be watched, and, as the temperature of the water varies a great deal in only a few seconds of time, the supply cocks frequently adjusted to maintain an equal heat in the issuing water. It is beyond our province to go deeper into this matter; indeed, it is entirely a doctor's question, and the preceding remarks are only intended to help the student to intelligently interpret such people's wishes when called upon to construct anything special for the treatment of poor suffering humanity. The supply-pipes, cocks and thermometers, which are not shown in the figure, should be fixed on the surface of the walls and not hidden from view, although in some cases the hot water pipes would require to be treated so that patients could not burn themselves by falling against them.

Turkish Baths.

This part of our subject is much too large to be dealt with in a short lecture, and neither can it be called a branch of plumbing excepting so far as fitting up the water appliances extends. A few remarks, however, will not be out of place, and will help the student to better grasp the requirements of such institutions. To begin with, the building must have special rooms, each of which must be thoroughly ventilated, capable of being heated to any degree of temperature from 60 degs. to 260 degs. Fahr., with all necessary W.C.'s, ordinary lavatory appliances, in addition to others for the treatment of the bather, and which in this case may be called special. A small entrance lobby should be provided in which coat, hat, boots, &c., can be left, or, if in a private house or small hotel and space does not allow for this, they can be left in the dressing-room. If this is very far away from the bath-room thick wraps should be used, especially when cold draughty corridors have to be traversed. Inside the lobby should be a room heated to an ordinary temperature in which the bather can undress, redress, attend to his toilet, and lounge (after bathing) until he has got over the fatigue and the heat of the body is reduced to its normal temperature. A second room, heated to about 110 degs. to 120 degs. Fahr., to be fitted up with a marble bench, on which the bather is shampooed, rubbed and kneaded. In or near this room should be fitted a combination plunge, needle, shower, spray and douche bath. Outside of the same room, but not in direct communication with it, should be fitted a W.C. and lavatory. In more ambitious arrangements a plunge or swimming bath is a great improvement either in or adjoining the above room, the air temperature being kept the same. A third room, heated to about 240 degs. to 260 degs., is necessary for inducing perspiration. With regard to the construction of the room the

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walls (if external) are best if built hollow to prevent radiation of heat. For the same reason double glazed windows should be provided. The floors, walls and ceiling should be of some material that will resist the action of water. The walls may be covered with glazed tiles, but those that are unglazed are best for the floor, and if they have slightly roughened surfaces there is less liability of the bather taking an involuntary slide.

As the whole should be kept scrupulously clean, and has to be frequently washed with copious streams of water, the floor should be laid to fall to an outlet, and if a plunge or swimming bath is below the floor level a raised kerb should be fixed to prevent floor washings fouling the contents. Although the floor of the hottest room should be kept as clean as the others, the washing should not be done either at the time of, or just before, being used. The temperature of this room being higher than that of boiling water any moisture in the air would be at steam heat and scald the bather. Where this "sudatorium" or sweating room is used by several people, either together or in quick succession, the odours will become very unpleasant, so that it is very necessary to make ample provision for ventilation to keep continually changing the air. The foul air should be extracted through gratings in the floor connected to a shaft with an induced air current. Although the ventilation should be thorough, it should not be too violent, so that the motion of air in the room approaches to a draught as felt by the occupant or bather. The other rooms should be ventilated as usually practised; but here again provision must be made to prevent anything that approaches a draught which would give a "chill" to the person or persons in them.

With regard to heating the rooms special methods have to be applied. A hot water boiler with radiators would get up sufficient heat for the outside rooms, providing that the same boiler was not used for supplying the hot water to the bathing appliances, and which would cause the temperature to vary to a considerable degree. But for the sweating room the temperature of the air should be considerably above that of boiling water. Hence a steam boiler with super heater and tubes, or a hot air stove, must be used. In either case fresh air passes through the heating medium into the rooms as may be found desirable, the current being regulated by "hit-and-miss" gratings.

Very few establishments have steam boilers, and for this reason stoves are generally used for heating the air for Turkish baths.

In a small sweating room an ordinary laundry ironing stove can be fixed for heating, but such stoves are not entirely satisfactory and not at all suitable for large establishments. The stove will get red hot and "burn" the air, thus destroying one of its constituents, oxygen, which is necessary for supporting life. Although the air has to be very hot it does not necessarily follow that it must be so changed that people would be suffocated if they took a bath under such conditions. And again, the ventilation of a room could not be made efficient without sacrificing the heat engendered by the stove. Another evil is, the heated air rising from the stove is replaced by the other, and cooler, in the room, so that the same air is heated over and over again. It also gradually becomes more unfit for breathing owing to pollution by emanations from the bather's body. The room is not at the proper temperature throughout. For these reasons the use of such stoves can be considered only as makeshift arrangements.

The best regulated establishments are heated by means of air which has passed through or round stoves specially constructed. An ordinary fireclay retort, as used in gas manufactories, can be fixed, the heat being applied outside, and the air to be heated passing through to the ducts leading to the hot chamber. Or the retort can be fired inside and the air passed outside. There are a few cast iron stoves in the market which are very suitable for heating air for Turkish baths. Some of these, known as "Gill Stoves," are built in chambers having fresh air inlet channels, or grated openings, and other channels constructed for conducting the heated air to the desired room. These stoves are usually fixed in small chambers with very little space between the heater and the walls at the sides. By some, it would, perhaps, be considered as having a tendency to waste the heat, but it is much better to have the chamber so large that a man can get inside to clean, or sweep out the dust which accumulates to a serious extent inside, and also on the heater. Not only is the heating power minimised, but the dust, which often consists of matter having a vegetable origin, is scorched, and the fumes mixing with the heated air passing into the sudatorium is inspired by the bather to his injury.

The heated air should not enter at one point but be divided into streams entering at several places, and so arranged that some parts of the room are hotter than the others. The bather can then select that which is most suitable for him. In small establishments the heating should be commenced some considerable time before the room is used, otherwise the walls would be so cold as to feel chilly when approached. In large establishments special hot air flues can be constructed in the walls and thus warm them. The heat radiating from such walls would help to keep up the temperature of the room.

There are a great many other details in connection with Turkish baths, but having dealt with a few of the leading points, it is not necessary to proceed further with the subject, it having so little interest for ordinary plumbers. The construction of such works is generally placed in the hands of those who have a special knowledge of the matter.

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WASH-HAND BASINS.

THE position in which to fix wash-hand basins should always be well considered. No matter how well they may be fitted up and pains taken to prevent bad air escaping from them, they are always liable to be improperly used, more especially when fixed in bedrooms. It is not only in what may be called the mansions of the wealthy where evils have been discovered, but in some public institutions. Whenever inspecting a house, and the writer finds wash basins fixed in bedrooms, and having waste-pipes and water supply-cocks attached to them, he always suspects that the servants empty the contents of the pot de chambre into the basins, and in the majority of instances finds this to be the case. Frequently complaints of smells in such places have been made and men sent to seek the cause, but could find nothing wrong with the trapping or disconnection of the waste water-pipes. On holding a lighted match so as to touch the inside of the basins the odour of urine has at once become noticeable, thus proving beyond doubt what the servants very often take great pains to deny. For this reason alone we are led to the conclusion that wash basins should never be fixed in bedrooms. This applies not only to basins with waste-pipes emptying into gully-traps outside the house, but also to those which are arranged to discharge into slop buckets placed inside the enclosures. On opening the doors of the latter kind of fitting, the writer has found the stench almost equal to that of a cesspool. As an excuse for the servants who practice the above filthy act, it must be said, in most cases no proper convenience is provided for the reception of slops, or when provided, it is at such a distance from the rooms that they, the servants, are tempted to do that which gives them the least trouble.

As an example of the same evil on a larger scale may be taken a school where, in each dormitory, is a range of 10 or 12 basins. The waste-pipe from each basin empties into a lead-

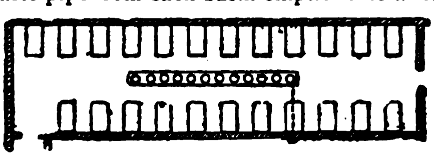

FIG. 555.

lined wooden trough, which has a trap fixed at one end and a 2 in. waste-pipe from that to an open hopper head outside. The trough is lined inside with black, ill-smelling slime; and here, again, the odours are suggestive of urine. Each dormitory has 20 to 24 beds, and the nearest sink is in a wing remote from the rooms. Fig. 555, is a sketch plan of one of the dormitories. Although these and similar arrangements may not actually breed any disease they cannot, under the given circumstances, be accepted as being sanitary, and should be condemned.

Wash basins with waste-pipes to them should be fixed in properly appointed dressing-rooms or lavatories, and, to be thorough in reasoning, such rooms should not be in direct communication with sleeping apartments. In these latter, portable conveniences should be provided. Wash basins in various parts of a house are a great convenience for use during the daytime, and often save the disarrangement of those in the bedrooms. Some people like them in each W.C., but one or more should always be next to a billiard-room and one near the garden entrance. In country mansions a similar fitting should be in the gun-room, and in

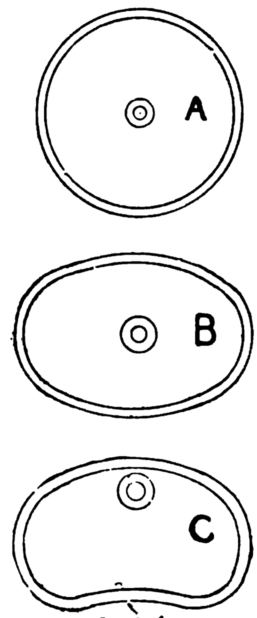

FIG 556

large establishments one should be fixed for the cook or chef's use. Men-servants' quarters should have similar conveniences, if only to avoid maid-servants having to enter the rooms two or three times a day to empty the slops and provide clean water, which must be done when the men are dressing for their various duties. Where men-servants have to sleep in the butler's pantry, which, although very objectionable, frequently has to be done for guarding the plate, proper conveniences should be provided for them. A wash basin for their use would do away with the necessity of using bowls, in which plate and dinner glasses are

washed, when shaving and washing preparatory to donning their livery.

With regard to the materials for wash basins little can be said. At one large mansion, in which the writer is interested, they are all to be hewn out of solid blocks of various kinds of marble. In a few cases they have been made of metal, but in general, porcelain is the material used. Than this there is nothing better. It is not porous, nor absorbent, and does not change colour to such an extent as marble, although inferior goods go crazy in the glazing. Some kinds of water will also stain the porcelain, but this is difficult to avoid. There are clients who have a preference for highly decorated basins, but in the writer's opinion those which are white or cream tinted are the best, as anything that has a tendency to hide or disguise dirt in any form is objectionable.

A few years ago all basins were made round on plan, as A, Fig. 556. Such are not at all comfortable to use, and this led to the introduction of the so-called oval, or "elbow-room," shown at B. During these last few years a form of basin has been introduced the plan of which is shown at C. Anyone having used this latter basin will have found it better than the others. When dipping the hands to rinse the face the arms do not scrape on the edge, and water running off the wet arms is not so liable to run onto the floor or the user's dress.

The size of wash basins must be governed by the circumstances for which they are required. Those in W.C.'s or by the garden entrance need be only 13 in. to 15 in. in diameter, but for toilet purposes they should be much larger. At some works in hand at the present time, we are fixing basins shaped as at B, Fig. 556, 28 in. by 22 in., measured inside the top rim, by 8 in. deep. And these are not at all too large, especially when fitted up with head shampooing arrangements. Under these latter conditions the basin shown at C, has an advantage over the others shown in the figure.

The height at which basins should be fixed has to be varied. Usually this is about 2 ft. 6in. to 2 ft. 8 in. This answers very well for general

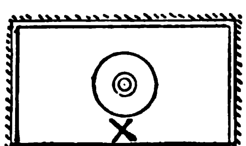

FIG 557

use, but when fitted in dressing-rooms and used for shampooing the head 2 ft. 2 in. to 2 ft. 4 in. is quite high enough. A sitting position is usually adopted during the operation and it is necessary for the chin to be inside the top rim for the water to run into the bowl. This detail is here dealt with as numbers of basins are fixed about 2ft. 10in. above the floor and are found to be most uncomfortable to use. Another objectionable detail in this connection is the wide margin between the front of the lavatory top and the inside of the basin. During these last few days two such cases have come under the writer's notice. Fig. 557 shows a basin with a marble top and the space at X is 6¾ in. Another

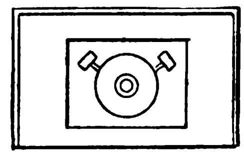

FIG 558

example is fixed in an earl's dressing-room and is shown by Fig. 558. The basin has a porcelain top, oblong in shape, and has a marble slab fitted over as shown in the figure. The space from the inside of the bowl to the front edge of the marble is 6½ inches. The evil is aggravated by the thickness of the marble top and the cabinet enclosure, which is made for holding slippers and other matters, which is not recessed or otherwise constructed in front for the knees and toes. Fig. 559 is a section drawn to a larger scale to explain this. The height from the floor to the top of the marble is 2ft. 8in.

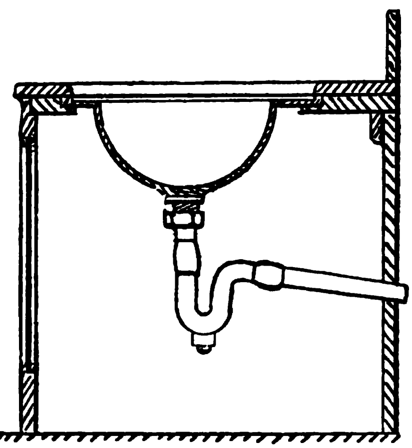

FIG. 559.

The whole is most elaborately fitted up and looks very nice but is most uncomfortable to use. The user has to stand with all the weight on the toes and when washing some of the water is splashed onto the floor or his dress. The space in front of a wash-basin should not exceed 3in., but in the case of a marble top, that point is rendered very weak. Those who have much of this kind of work to do know that numbers of such tops get broken at the point mentioned either in transit or in the act of bedding them in their positions. In the writer's knowledge such breakages amount to a serious item of expense, and with the object of

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minimising this loss a great many marble tops are made with 4 in. margins in front.

A great many ordinary wash basins have the outer edges of the rims turned slightly downwards. With such it is very difficult to make a good joint between the marble or slate top and the basin. Should the material used for the joint become defective, and sooner or later it will do so, water will pass through and make any woodwork beneath quite rotten or so saturated with soapy water as to smell offensive. When the outer edge of the rim is made to turn slightly upwards any water getting into the joint can more readily run back into the basin. Another weak detail in construction is the overflow arm. This is generally attached to the outside, close to the rim, and a few holes or perforations are made in the side of the basin for any excess of water to flow through and into a pipe fixed for conveying it away. On looking into these holes they always present a dirty appearance and an unpleasant odour of stale soap is found to issue from them. To hide the dirty appearance referred to, some of the better class of basins have what is known as "shell" overflows. That is, instead of having the exposed holes, a piece of the same material as the basin is moulded to the shape of a shell and fixed over the opening on the top side, an open space being left on the under side for the water to pass through. This does away with the dirty appearance referred to but does not get rid of the unsanitary odours. The shell is also objectionable by reason of its preventing the inside air escaping. When the overflow pipe is attached to the trap, as shown in Fig. 102 in an earlier lecture, the bottom end of the pipe is sealed by the water in the trap and, when the basin is filled to overflowing, both ends being covered, the pent up air cannot escape. The pipe is then "air-bound" and rendered useless. To prevent this, small air holes have been made either in the shells or the tops of the overflow arms. Some plumbers will get over the trouble by leaving the joint of the arm to the pipe unmade for the air to escape in that way. Some wash basins have brass grated overflow connections and others have channels formed in the material of which the basins are made. These channels lead down and are connected to the waste outlet and are not at all good, as they cannot be cleaned when dirty, and it is difficult to remove any obstructions when they are choked.

None of the arrangements that have been described can be considered as being thoroughly sanitary. This applies not only to our present subject, but to all kinds of sanitary fittings having overflows down which dirty water passes and which cannot be readily cleaned inside. A leading sanitary engineer has designed one which is open at the top, so that a small mop or brush can be used for scrubbing the inside of the pipe. Although open, provision is made for preventing small pieces of soap or other matters falling in and blocking up the pipe. Fireclay and pottery-ware sinks with attached overflows have been treated in the same way. When writing on baths, the same detail was referred to in that connection.

Standing or trumpet-mouthed combined waste and overflow pipes have also been designed for both baths and wash basins. They are made removable, so that they can be lifted out, scalded and cleaned. In places used by the public generally, this detail becomes of great importance, as we do not know to what extent certain diseases can be transmitted by the use of either baths or wash basins which are not so constructed that every part can be periodically cleaned and disinfected. To no institutions does this apply more forcibly than to hospitals and similar places, where people suffering from various diseases use the same sanitary conveniences, and which become the medium for communicating these diseases to other persons. So that the importance of these remarks may be fully realised, it may be mentioned that in some institutions the nurses and attendants are not allowed to use the same lavatory conveniences that are used by the patients.

Another unsatisfactory detail in connection with wash basins is the size of the holes in the bottoms. Nearly all makers err in having them so that only a very small waste-pipe can be attached. When writing on flushing drains, it was stated "even the small quantity of water from a wash basin should be made to contribute its portion of the work of drain cleansing." Forgetful of this rule, basins are being made with such very small waste holes that the largest size plug or connection that can be used has a diameter of only about ½ in. True, in fixing such fittings, large size traps and waste-pipes are sometimes used, but these avail nothing if the water cannot pass quickly out of the basins. Under these conditions the traps readily choke up (see lecture on "Traps" and text accompanying Figs. 270 to 275) and the waste-pipes become foul inside. And, again, a basin that takes a long time to empty will try the users patience to the utmost extent, and when the water has finally disappeared the sides are found to be covered with black, or dirty looking, soap curds, which have to be washed away by partly filling the basin with clean water and again waiting for that to flow away. The reasons given and suggested are sufficient to prove the necessity of having good sized waste holes. These should be large enough for the connection, trap, and waste-pipe to have a waterway throughout of at least 2 in. in diameter.

When basins are of a round shape there is some difficulty in getting the water to flow away quickly owing to a vortex forming in the centre. With those shaped as shown by C, Fig. 556, this whirling motion does not take place to any serious extent, and when the outlet opening is nearer still to the side than shown in the sketch, or is partly in the side, as mentioned when writing on bath wastes, and illustrated by the

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outlet at the end of Fig. 543, the motion is entirely stopped and the basin empties very quickly.

All the basins that we have dealt with are for fixing with marble, slate, or other tops to them.

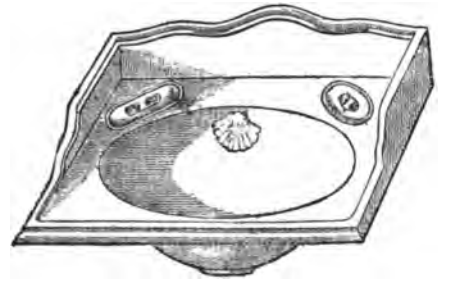

FIG. 560.

There are others with porcelain tops which are attached to and form a part of the basins. That shown in Figs. 558 and 559, is of this description. A view of a similar one, but with skirtings, is shown by Fig. 560, and one for fixing in an angle by Fig. 561. From a sanitary point of view these are much better than the basins with separate tops, as there are no objectionable spaces for dirty matter to accumulate in. For comfort they are too small, owing to the difficulty of producing them of a large size and with plenty of top surface for holding toilet brushes, soap, and the usual conveniences, and also for catching any water that may be splashed about when being used. As a considerable amount of dirty matter will sometimes stick to the inside of basins they have been made with hollow rims, round which the incoming water passes and escapes through the perforations or openings made for the purpose. To rinse the dirt off the sides the water is turned on for a few seconds, when the basins are flushed similar to those of W.C.'s. Provided the matter has not dried on the flush will wash it away, but will not do so when once it has dried. Another way for flushing is to have a brass spreader connected to the back of the basin. The service-pipe is attached to this, and the water spreads around, thus taking away all objectionable matter, similar to a W.C. basin with a fanned flusher.

The basins shown by Figs. 560 and 561 have attached skirtings, which are a great advantage. These being of one piece with the rest of the fitting there are no joints to become defective and allow water to pass through. They have also raised beads on the front edges, so that any water that is splashed about must run back into the basins instead of onto the floor. Soap and brush sinkings are also provided, as shown in the figures, and porcelain covers are generally sent with them. The latter are perfectly useless, and generally found to be in the way, with the result that they are purposely thrown aside or become broken by accidentally falling about. A few years ago it was usual to have small porcelain gratings in the above sinkings for the soap and brushes to lie upon, but the general practice now is to have raised bars moulded in the bottom of the sinkings for keeping the soap, &c., from being constantly wetted. On looking over manufacturers' catalogues a great many of the illustrations show small holes in the sides of the basins. These represent waste pipes from the above sinkings. In practice large numbers of fittings are found to be so made, and in use the holes are in a chronic state of being choked with soap in a semi-liquid condition and emitting unpleasant odours. The better class of manufacturers have now discarded these

FIG. 561.

small waste pipes, and form small channels on the surface of the top for the drainings to run from the sinkings into the basins. These are similar to those shown in Fig. 562.

Two of these so-called "cabinet wash basins" have been shown as examples of their kind, but they can be had in a great variety of forms which would be too tedious to describe. Suffice it to say that on looking through one merchant's book no less than 97 different patterns are illustrated. Their title of "cabinet" is rather misleading, as, although large numbers have cabinet enclosures, a great many are supported on skeleton brackets fixed to the walls, thus leaving the spaces beneath quite open, so that they can be cleaned with the rest of the floors. For fixing in private dressing-rooms unenclosed wash basins are not much liked, but from a sanitary view they are much superior to those which have cupboards to them. On opening the doors of the latter they are generally found to be filled with all manner of things in which empty, or half empty, medicine or lotion bottles, slippers, pieces of cracked crockery, dirty housemaids' dusters, and such things are conspicuous. Some enclosures have drawers to them, in which are kept sundry toilet necessaries and articles of clothing. The latter is a very bad practice as they become damp and unfitted for wear until they have been again aired ready for use. When the water cocks and pipes are leaking injury is done by the escaping water, and the plumber has great difficulty in making any repairs. As an excuse for enclosing lavatory basins it must be admitted that no matter how skilful the plumber may be and how smartly he may execute his work it

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does not look nice when exposed to view and is fixed in a highly decorated and upholstered room. Perhaps some day we shall be able to overcome this matter by fixing basins with electro or nickel-plated attachments which will not look unsightly, and which I believe is done in high class work of this description in some of the principal American towns, both in hotels and private mansions.

Although the entire abolition of enclosures to cabinet wash basins may not come into general practice, there is no reason why they should not be reduced in size, as shown by Fig. 562, and their use confined to simply hiding the plumber's pipes and fittings beanth the basin. Not only would less room be occupied by the fitting, but it would be more convenient to use as the person could stand closer, when leaning over the basin,

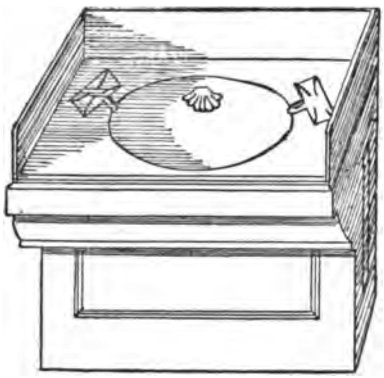

FIG. 562.

on account of the space beneath being open for the feet and knees. The evils of ordinary arrangements were dealt with above when describing the fitting shown by Fig. 559. When fixing that shown by Fig. 562, it must be securely fixed to the back wall, otherwise it would have a tendency to fall forward. There are firms of ironfounders who sell cast-iron brackets for fixing to walls for supporting wash basins. Those the writer has seen were very neat and strong and with them no enclosures are necessary excepting where it is desired to hide the plumber's work beneath. In such cases the enclosure could be made as shown by Fig. 562, and, if in one piece, the whole could be removed for access to the pipes, without much trouble. This would also be more sanitary than having hinged doors which could be easily opened and which would enable people to make "glory holes" of the places for everything that had not any immediate use.

There are several ways, and a variety of fittings used for emptying wash basins. Many are good, but a considerable number are not so. The great trouble is to get people to understand the many points that should always be borne in mind by plumbers and engineers when designing and executing sanitary works. In all cases cleanliness should be the goal striven for. Every precaution should be taken to keep everything clean. Not only wash basins and their surroundings, but the traps beneath, the waste pipes, gulley or interceptor traps, and drains from them extending to the sewers, and even the sewers themselves, should be kept unfouled. Some portions can be seen and are attended to when dirty. The invisible parts are out of sight and rarely, if ever, considered. Sometimes standing orders are given for the plumber and drain man to attend periodically and wash and disinfect all channels in connection with sewage and waste water. The cleaning may be thoroughly done, but a few hours afterwards the evils again begin to accumulate. If every person could be made to grasp the vital importance of clean drains, waste pipes, and sanitary fittings, and that the best means to that end is to make use of all the water, either dirty or otherwise, at their command to scour all the passages it travels through, we should then be better off from a hygienic point of view. We could not very well get on without a great many of our present day sanitary fittings, many of which are patented; but an article that is so patented, no matter how good it may be, is perfectly useless for the above purposes if there is not a proper water supply attached. And again, patented or not, sanitary appliances that empty slowly, so that water only dribbles away, foul those parts which would be kept fairly clean under better arrangements. This matter has frequently been referred to in these lectures, but no apology from the writer for repetition is necessary, as he is constantly meeting people who never attempt to be, or fail to appreciate the importance of being, thorough in their undertakings, preferring to simply deal with superficial details. These remarks apply to all kinds of plumbers' or sanitary fittings, including wash basins. The evils are doubtless experienced almost daily by readers in all parts.

To those of moderate experience the matter can be made clearer by means of drawings. Fig. 563, is a sketch of a wash basin, showing what the writer is constantly running against. In the basin a ¾ in. plug and waste connection, the union of which is soldered to a 2 in. pipe which is joined onto and forms the "dip" of a 7 in. deep lead D trap. In the cheek of the trap a large size brass cap and screw is soldered for access for removing the filth that accumulates inside. The waste pipe is often found to be reduced as shown in the figure. The plug being small the basin empties slowly, the floating soap-curds enter the trap, where they decompose and remain until the outlet becomes choked, and the plumber is sent for to remove the stoppage. If the trap becomes foul inside the waste from it must be in a similar condition. The gulley trap into which the latter empties, and the drain from it is also rendered very dirty. In a great many instances cross bars are fixed inside the waste connection to the basin, for preventing rings, &c., passing through,

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thus further reducing the waterway. Under such conditions the basins take from a half to two minutes to empty. This time being further extended when the waste passages are partially choked. The plumber is in constant requisition to remove certain matters out of the trap and pipe which, under proper arrangements, would have been washed away into the sewers or wherever the waste water is discharged The remedy for all this is to have a large, clear way passage for the waste water to leave the basin and the

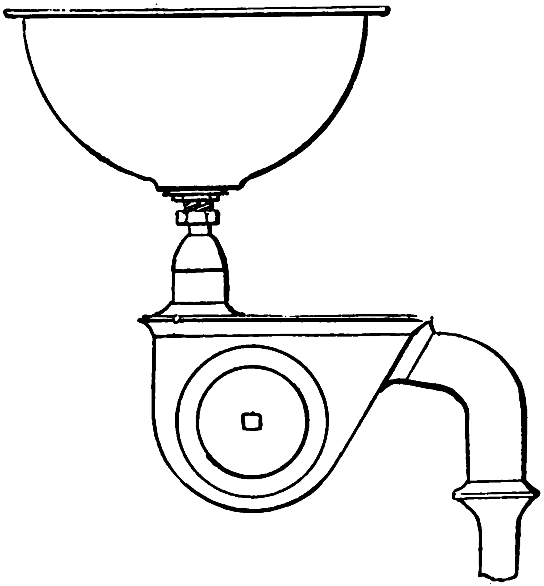

FIG. 563.

gulley trap, and drains which receive the waste to be much smaller in size than is usually practised.. Referring to Fig. 564, the plug and waste connection are shown in section, and are apparently larger than the trap and pipe beneath. The enlargement is necessary because of the space occupied by the grating, which must be fixed for intercepting pieces of soap or anything large, which would choke the pipe. The plug is best made of "woodite," "ebonite," or some similar material, as if made of brass, or any hard metal, it would in falling break the basin. On looking into the details of the waste connection it will be noticed that there are no projections inside or sharp edges for the escaping water to impinge against, or spaces in which filth can accumulate. Even these small details must be taken into consideration if we want to be thorough in our efforts to reach perfection. The union to the waste connection is best when made like those used by steam engineers, that is, "ground in," and thus avoid having to use grummets or washers made either of hemp or leather. To prevent the plug being lost it should have a chain attached, and this is the principal objection to plug wastes. The links of the chain get filled with ill-smelling matter, and when the basin is being used the chain is caught by the fingers and the plug jerked out of its place, thus emptying the basin. The first evil can be minimised by frequently scrubbing the chain with hot water, soap, and a brush, and the second one by being careful when using the basin. Both evils can be avoided by using sunk plugs with keyed spindles. The plug has a knob below the basin level, by which the basin is emptied. Some people object to this arrangement as they have to put their hands into the water, sometimes after usage by someone else, to empty the basin for re use. It will be noticed that the trap and waste pipe are of the same size, and the waterway through them is what is called "full bore" throughout. A piece is cut out of the bottom of the trap to show the so-called screw cap in section, and which represents the ordinary market form of such fittings. The plug being hollow, filth can lodge in it, and the sharp edges inside the trap to a certain extent retard the velocity of the water passing through and partially destroy its scouring,or cleansing force. Fig. 565, is an enlarged section showing the plug as improved upon by two or three of our leading engineers.

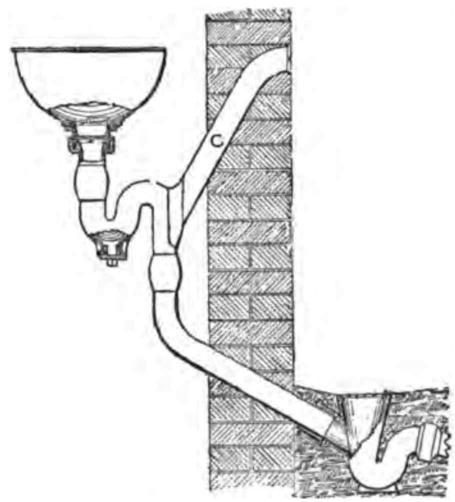

FIG. 564.

The plug A, is solid, and the end B, is made to the hollowness of the inside of the trap. The short branch pipe C, Fig. 564, and the continuation of the waste pipe will be referred to further on.

There are several patented waste valves for attaching to wash basins, but it is not necessary that we should refer to all of them. Two or three examples will be sufficient for our purpose. One is very similar to that of a valve W.C. By pulling up a knob a lever is raised; this acts on a "tumbler," opens the valve full-bore, and empties the basin very quickly. Another one, which is patented, is shown by Fig.

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566. On raising the lever D, by means of a knob above the basin top, the valve opens full bore and the water runs away in a few seconds. The grating at E is made very large, and the perforations have a waterway through them which, in the aggregate, exceeds that through the trap and waste pipe.

Another kind of so-called "quick waste discharging apparatus" for wash basins is similar to that shown at K M, Fig. 542. Although much used this arrangement is unsanitary. The reasons were given when writing on bath wastes.

A great many basins have ordinary stop valves, or cocks, for emptying. These are soldered into the waste pipes and turned by means of long keys or spindles with knobs or levers fixed through the tops of the basins. With these appliances the traps have to be fixed some little distance away from the basins. The intervening pipes are found to give off musty, soapy odours, and the practice has been condemned by many leading sanitarians.

When designing or fitting up wash basin waste arrangements the principal object to be gained is to make them so that they will quickly empty for the reasons already given. A further detail is to have a trap to each basin, the trap being as close to the basin as can conveniently be fixed. The overflow from the basin should be so arranged that it can be periodically cleansed inside. The traps and waste fittings should be what is commonly expressed as being self-

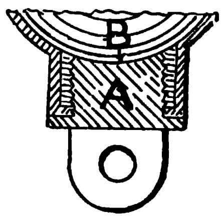

FIG. 565.

cleansing, which means that the passing water will, by its friction against the inside, scour off any adhering matters, the water running at such speed and passing away so quickly that soap curds and dirty matters held in suspension have not time to separate or become deposited in any point. Two examples of constructive details were shown by Figs. 102 and 103 in an earlier lecture, but we may refer to others at a future time.

Some years ago, so-called "tip-up" basins were invented by a prominent sanitary plumber. They are now made by almost all manufacturers of sanitary fittings. These basins have a pair of brass bushes keyed onto the sides. These bushes rest on trunnions fastened onto deal tops, and the basins are so hung that when out of use, or when filled with water, the tops are horizontal. To empty them they are "tipped up," by raising the front edge, by means of the lip at F, when the contents are emptied into a "receiver" beneath, no waste holes in the bottoms, nor plugs nor valves being at all necessary. When first introduced the receivers were made of wood and lined with zinc or lead. These were found to be so very foul in use that they were condemned as being unsanitary, more especially when several basins were fixed over one trough. Improvements were then made, and each basin had its own outer chamber, this being generally made of sheet zinc, but success was only partial. This chamber was then made of porcelain, the same as the basin. Those of early introduction were found to have many objectionable points, the principal one being the dirty condition of the insides caused by the splashings from the basins. The outsides of the latter also got very dirty. Later introductions have been considerably improved. The section of the combination is shown by Fig. 567, and will help to explain the following details. The outlet of the receiver is at the back at G instead of the centre of the bottom. This prevents so much splashing, and consequent fouling inside, and also the water washing over the front, when being emptied, onto the person using it. The basin has a better

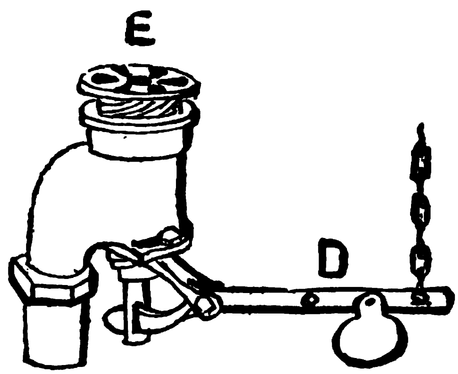

FIG. 566.

arrangement, so that the overflow water drops into the receiver instead of running down the outside of the basin, and the latter can be lifted off its trunnions for washing and cleansing. For hard wear in public lavatories these fittings answer very well, and as they are emptied very quickly they answer one of the points that was raised above. When under the charge of an attendant who knows his duties, and executes them, very few odours escape from the receivers, simply from the fact that being kept clean there is nothing to cause a smell. There are numbers of places, where tip-up basins are fixed, that present woeful appearances from the wretched way that repairs are executed. If a basin or receiver gets broken instead of sending to the original manufacturers to have it replaced, or for a duplicate, some one else is sent for who buys a basin anywhere and takes very little pains to

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get an exact copy of the original. The result is that the basin may be too large or too small to fit the marble top, or is out of shape, and frequently of a different tint or colour, or not properly balanced owing to the trunnions being out of centre. How often when travelling about one runs against a lavatory with basins in ranges, each bearing a different firm's name, and the whole presenting a dilapidated appearance. Surely it would be much better, when replacing anything broken, to send to the manufacturers of the original, who for the sake of keeping up their reputation would take every pains to get a satisfactory result. These remarks apply to repairs of all kinds, and recall to memory a remark by Mr. C. J. Fergusson, an architect living in Carlisle, who, at a lecture given by the writer in 1889 at Carlisle, "suggested that ordinary lead pipes, traps, and such fittings should never be repaired; new ones should be substituted." If this were done everything would then be in good working condition and present a respectable appearance, and there is not the least doubt this would eventually be found to be true economy.

Mention has already been made as to enclosing wash basins, and we may here refer again

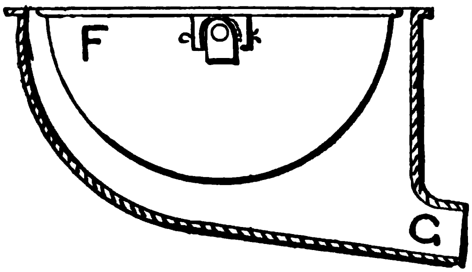

FIG. 567.

to the subject, but assuming the basins to be in ranges and fixed in schools and other places where they are subjected to hard and, it may be said, unfair usage. Because of this latter many fittings are made clumsily, and which are entirely unsuited for their purpose. One has been referred to, see the text accompanying Fig. 55. It is all very well to aim at strength of, and simplicity in, construction, but with our present knowledge of sanitation and the important part that plumbers' work plays in the matter it must surely be looked upon as a crime to do anything that may lead to ill-health. When sanitary fittings are used by large numbers of people, either adults or children, such fittings not being properly constructed, it is terrible to think of the evils that may follow. We are constantly being told of various ways by which disease can be transmitted, the latest being that kissing is dangerous. Of course we cannot have a separate W.C., bath, or wash basin for every person, but we can take every precaution for preventing those fittings being the vehicle for conveying the germs of disease from one person to another. Every part that comes in contact with the person of the user can be kept clean by an attendant or servant the plumber can do his work in a satisfactory manner, but the selection of the fittings he uses are very often beyond his control, although in some cases he may be held responsible for that also. One of the commonest found ranges of wash basins is where they all empty into a horizontal pipe which is very large, is fixed a considerable distance away, thus necessitating long branch waste pipes, and which do not have any traps on them and which can become the medium for transmitting disease germs.

Fig. 568 is a sketch of a range of wash basins similar to those often found in public elementary schools. At first sight the fitting may appear to the uninitiated as being good, but it is not so.

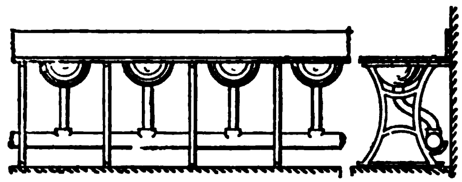

FIG. 568.

The basins made of cast iron and enamelled inside; the bearers, legs and waste pipes being all cast-iron, and the top of slate, the whole is very strong and difficult to injure even by the most determined schoolboy who is bent on mischief. Not having any enclosure the whole is open for inspection, but on looking into the construction it will be seen at a glance that there are corners and places on and near the floor that are not easily accessible for cleaning. Large numbers of such fittings are found to harbour dust and dirt which, on being wetted by splashings from the basins, or even when washing down the floors, is converted into mud in which fungoids can propagate. The floor space beneath can neither be swept nor washed in a proper manner, hence an accumulation of foul matter which, under better conditions, would not be. To prevent these latter evils, the basins and top should be supported on brackets fixed to the back wall instead of having leg supports, and the angles formed by the floor and walls to have hollowed fillets, as shown at A, Fig. 569. The writer has advocated these fillets for several years past and is interested to know that several architects apply the principle in all cases where it is deemed advisable to do so. In a recently constructed wing of a large hospital, the whole of the wards, passages, nurses' and administration rooms have been so arranged under the architect's instructions that it is difficult for any microbe to find a corner to rest in. No doubt this principle will extend in the future, and it ought to be introduced into all dwelling houses, not only for health's sake, but to save the servant's time picking dirt out of corners by means of their hair-pins when beyond the reach

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of a scrubbing brush, or else lay under the ban of being dirty and slovenly.

In Fig. 568 the horizontal waste pipe is too large, has no fall so that it can drain empty, is fixed some distance from the basins, and is not trapped to prevent an incurrent of air through the waste pipes. This air is rendered unfit for breathing by having passed over the fouled, slimy, insides of the waste pipes, to which scales from sores on the children's hands, heads, and faces may be adhering. In defiance of the

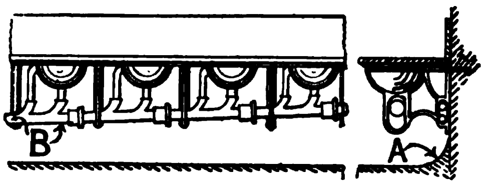

FIG. 569.

great spread of sanitary knowledge during the last few years, there are people who still maintain that traps are unnecessary under the above conditions. If they could only be persuaded to sink their crotchets and try a few practical experiments, even a lighted taper, or a piece of smouldering smoke paper, held over the ends of the waste and overflow pipes in wash basins would prove to them the fact of air passing inwards, more especially during those times or seasons when doors and windows are not kept open, they would have their confidence in their own ideas very much shaken. As for air having passed through a dirty waste pipe being harmless, those who uphold this would shudder at the idea of drinking any water, no matter how clean it was at starting, that had so passed. The air is as injurious for breathing as the water is for drinking.

Fig. 569 is a sketch showing a portion of a range of wash basins fixed to withstand hard wear, and which is without several of the objectionable details enumerated above. A further advantage is the absence of all woodwork, the supporting brackets being made of galvanised cast iron, with cross pieces made to proper shapes for carrying the basins. The cross pieces are so fixed that they can be taken away for renewing broken basins without having to remove the top, which, when made of marble, is frequently broken in the operation. The horizontal pipe B is fixed as close to the basins as possible to minimise the amount of internal surface which gets fouled in use. At the outlet end of this pipe a trap should be fixed to prevent an in-current of air. The whole being very strong and, standing independently of the floor, there are no places that cannot easily be cleaned. Although superior to a great number of the fittings met with in practice, the arrangement shown by Fig. 569 cannot be accepted as being so good as that shown by Fig. 102 in an earlier lecture, but the latter should be supported on brackets fixed to the back wall.

The surroundings of basin tops are worth a few remarks. Frequently we find the walls at the back and ends unsightly from the splashings they receive. Not only do they look dirty, but they get saturated with fouled water and emit faint odours. When the walls are painted the surface will blister and peel off, and when covered with tiles the latter almost invariably, after a time, become loose, owing to the fixing material swelling by being constantly wetted and forcing them off. Skirtings are usually fixed round marble and slate basin tops, but, as a rule, they are only about 4 in. high, although in some cases they may extend to 6 in. In a few instances these skirtings are 1 ft. 6 in. and 2 ft. high, and for good work should never be less. Mirrors are a convenience when fixed behind washbasins, and add to their smart appearance, but they should be so high that they would not be injured by being wetted.

When marble or slate tops are fixed, to either single or ranges of basins, they should be dished to a slight fall towards the centre and the skirtings rebated onto the top, as shown in section at F, Fig. 570. This will enable the splashed water which surrounds the basin when being used to flow into it, and prevent any passing through at the jointing. Plaster of Paris is usually the cement used for bedding marble, and this material, by being constantly wetted, very soon becomes useless and presents no obstacle to water passing through to saturate whatever is beneath. There is room for some one with an inventive genius to find out or manufacture some good substitute for plaster. The writer does not know of any suitable material. Whatever is used must not have any influence on the marble or stain it. Oil cement of various kinds has been used, by those who knew no better, resulting in the oil discolouring the marble and entirely destroying its appearance. With slate, oil cement is the best, but it should be coloured black to match the stone.

When the supply cocks to basins are fixed as shown at C, Fig. 570, they will frequently get

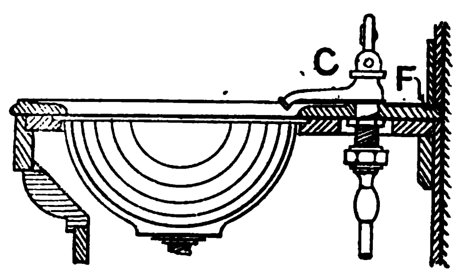

FIG. 570.

loose, and leave openings through which water can pass. Here, too, plaster is used for filling the annular space between the marble and the shank of the valve, and is found to be almost useless for either fixing the valve or preventing

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water passing through the hole in the marble. The valves become loosened in other ways besides the decay of the cementing material. That for hot water is in a constant state of motion owing to the expansion and contraction which takes place in the material as the temperature of the water varies. And, again, whatever kind of cock or valve is used there is always a strain upon it when being opened or shut, thus helping not only to destroy the soundness of the connection to the top, but to so loosen the screwed unions to the service pipes that they also will leak.

Various methods have been adopted with a view to overcoming the above weakness. Amongst the rest is one having a hollow space, enclosed with marble or slate, behind the top in which is fixed the pipes. To these are soldered the unions for the cocks or valves, the shanks of which pass through the riser or front of the enclosure, as shown by Fig. 571. Although the strength of the fixing is not increased, holes in the top, through which water can pass, are avoided. In a cheaper class of work the space is omitted, but in that case the pipes have to be embedded in the wall and the skirtings taken down whenever it is found necessary to do anything to them. The movement of the pipes will sometimes loosen the skirting, it rarely having any fixing beyond the plaster bed on the walls. When the skirtings have been

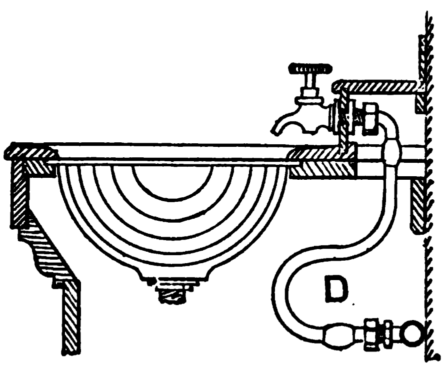

FIG. 571.

removed they are scarcely ever refixed as at first, and are frequently found to have a dilapidated appearance, especially when they have been broken in the taking down, or by any movement of the cocks in being used or by expansion. To this may be added the statement that when the brass shanks of the cocks fit the holes too tightly, they will, in expanding, cause a fracture of the marble. This remark applies in a great many instances in plumber's work, and was referred to when writing about the waste connections to fireclay baths.

Another experience of the writer's of marble work to basins, and the basins themselves when the tops are made in one piece of the same material, being broken has been traced to the hot water service pipe being made of iron and connected directly onto the supply valve.

The pull and thrust movement of the iron caused by expansion and contraction being the cause of the trouble. In practice it is found to be a good plan for adoption to use a brass or gun-metal union for joining onto the iron pipe, and connect onto the union of the supply valve by means of a short piece of lead pipe, bent to the shape of a swan neck, as shown at D, Fig. 571. By this there is not any direct thrust, as when the pipe is straight, and lead being softer than iron, will allow for the forces named to be spent at the bends. For best class work, a stop-cock, screwed at one end to fit the iron pipe, and having a union on the other end for soldering to the lead pipe, is used instead of the brass union for iron and lead. On this, it may be stated, that it is considered good practice to fix a stop-cock in each service pipe to a wash basin. The reasons for this are many, the principal being (*a*) the supply valves to basins are small and so frail that they frequently need repairs. Such can be done without shutting off the water to other fittings ; (*b*) the pressure of water on the supply valve is so great that on opening it the incoming water will splash over the edge of the basin on to the person, a stop-cock can be adjusted to prevent this ; (*c*) if the plug is in the waste, or the waste valve closed and the supply-cock is leaking, the basin will fill to overflowing, unless the overflow is a good one, which is very rarely found to be the case, a servant or an attendant can shut off the supply pending the arrival of the plumber ; and (*d*) when a basin is undergoing repairs it is not necessary to throw any others that may be in connection with it out of use during the time the work is being done.

Nearly every manufacturer of plumbers' brasswork has his own special designs for lavatory cocks and valves. Fig. 570, 571, and 572, show three different shapes. There are hundreds of others, but it would be a wearying task to attempt to describe even a tithe of them. We will deal only with a few which will be sufficient to illustrate some of the leading points which require consideration. The principles may first be dealt with under two headings, "self closing," and capable of being closed at pleasure, which can be again sub-divided into "quick-closing" and "slow-closing," and ordinary and "non-concussive." Self-closing valves are those which allow water to run so long as they are held open. These close with the water. The action is shown in section by the cock in Fig. 439, in an earlier lecture. That shown by Fig. 570 is of the commonest form and is known as the "Cam-action.

These latter valves close very suddenly by means of a spring, aided by the water pressure behind the inside valve, and make a loud chattering noise by setting up water hammer in the pipes when they are of considerable length. The valve shown in section, Fig. 439, does not

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make these disagreeable noises. On looking closely into the drawing it will be seen that the valve, in closing, slides past the inlet opening in the body of the cock and, comparatively speaking, more slowly arrests the velocity of the water. The advantages of self-closing valves are that they cannot be left open to overflow the

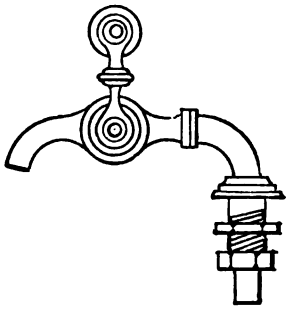

FIG. 572.

basins or to run water to waste. The disadvantages are that the user must hold the lever down so long as water is required to flow, and by people who are in a hurry or at all impatient they are not much liked.

The cocks that close at pleasure are ordinary "bib" or "urn" cocks of various forms, one of which is shown by Fig. 572, or valves as shown in section by Fig. 570. This latter valve has spoke knobs, or what is sometimes called a 'capstan head." No matter how soapy the user's hands may be he can get a good grip for

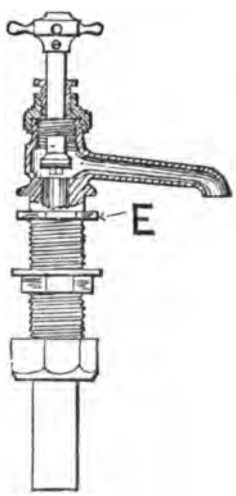

FIG. 573.

screwing down or closing the valve. This valve will resist a great water pressure and can have the washer renewed by taking off the top cap for access. The shoulder at E is for fitting into upper part of the hole in the basin top and is made square to resist being turned round by the force brought to bear when opening and shutting the valve. There is very little, if any, water-hammer with this valve. In spite of its good qualities, there are people who object to it on the ground that the knob has to be turned two or three times to either open or shut it. Because of this, an improved valve known as "quick closing," or "half turn," was introduced a few years ago.

Fig. 574 is an illustration of one kind and which is a good, strong, serviceable fitting. On turning the lever half-way round the valve is opened full bore. But when the water pressure is very high the valve will not always resist it, but will slightly open. When several are fixed on one service pipe and there are no air vessels to ease the concussion, or water hammer, they will open still more readily. It is reported that some makers have overcome this failing and make them to withstand a very high pressure.

It is not necessary for our purpose to dwell longer upon the principles underlying the con-

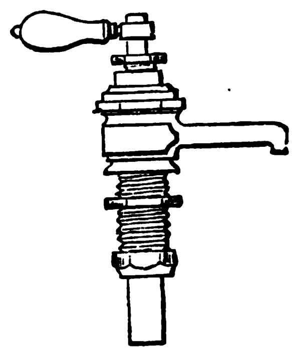

FIG. 574.

struction of lavatory valves which draw water over the basins, but there are several minor points about them which are worth consideration. We may deal firstly with their positions. When fixed at the sides of basins they come in the way of the user's elbows, and when at the back they should not be too high or project too far, or the user, when stooping, may risk knocking his head against them. When fixed on the top slab there are always dirty marks round the bases of the valves. These marks are aggravated by the verdigris which forms on the metal of which the valves are made. Because of the obstruction they present the basin tops cannot be easily cleaned down. To prevent the formation of verdigris the valves are sometimes electro—or nickel-plated, which consists of coating them with ordinary or nickel silver. When new such valves present a smart appearance, but after being used for some little time the plating turns black. Instead of using the proper material, which should be the same as used for cleaning silver goods, the servants or attendants scour the valves with brickdust,

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emery paper, and such unsuitable matter to the partial destruction of the coating, thus destroying the appearance of the whole fitting. And, again, if grit of any kind is used for cleaning the valves they wear out much sooner, and the spindles become loose and ricketty. That plain metal valves can be kept clean and made to look smart is proved by the appearance of those under the charge of careful servants and lavatory attendants, or even by those frequently seen in the bars of hotels and taverns. These look much nicer than those which have been plated, especially after they have been cleaned a few times. It may be added that valves and other fittings to a wash basin, which are plated, can be made to look as nearly as well as when

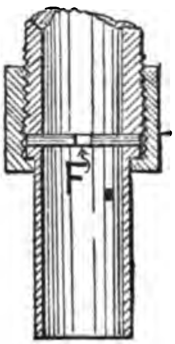

FIG. 575.

new if they are frequently washed with soap and water and rubbed with a clean, dry duster or wash-leather, no cleaning composition whatever being used.

Another detail in connection with the valves to draw water over the top of a basin is the nozzle. When cut off square, as shown by those in Figs. 571, 573, and 574, the water will hang up for a considerable length of time, a drip now and then leading to the assumption that the valve is leaking. Cases come to memory where such has occurred, and the plumber has been sent for to make repairs, which, after being done, had no result, the valves apparently leaking as badly as before. With the end of the nozzle cut as shown by that in Fig. 570, no such complaints arise. The shape of the latter nozzle is much better than any of the others that have been illustrated, in that the incoming water is directed into the centre of the basin and does not splash over the front so much as with those which play on the back side. The first portion of the water, coming in when the basin is empty, rushes round the bottom and over the front. As explained, the reason for this is due to the shape of the outlet end of the nozzle, but a great many plumbers will try to overcome the evil by "peaing" the valve. Their object is to break the velocity of the incoming water by reducing some portion of the waterway in the valve or its connections. There are several ways for doing this. One is to fix a stop-valve which can be partially closed, so as to break the velocity. Another is to fix a permanent obstruction which will always remain the same and not be subject to any variation, as is the case when a stop-cock is used. Fig. 575, is a section showing a portion of a lavatory valve with a "pea'd" washer. To make the illustration clear it may be explained that instead of using a "grummet" or ordinary washer, in the union onto the shank of the valve, a leaden one with a tiny hole, as shown at F, is substituted. The size of the hole is found by trial, a very small one, not much larger than if made by a pin, is tried first, and this is enlarged until it is found to be the right size to overcome the evil and yet not be too small to prevent sufficient water passing in a reasonable time.

There are several kinds of valves made for filling wash basins otherwise than over the top. Some of these are arranged similarly to the cocks supplying the bath illustrated by Fig. 544. There are serious objections to this method which have been dealt with in the text accompanying the latter figure, and also in my book, "Plumbing Practice," so we need not repeat them. Another method is to attach the supply valves by means of a pipe, as shown by Fig. 576, to an arm formed on the earthenware basin. Although this has been much practised, it cannot be considered entirely satisfactory. The principal trouble arises from the difficulty of making a sound joint between the pipe and basin arms. No matter how made, this joint is frequently found to be leaking, and in numbers of cases the earthenware arm detached from the the basin. As the cost of replacing a basin of this kind is sometimes considerable, the

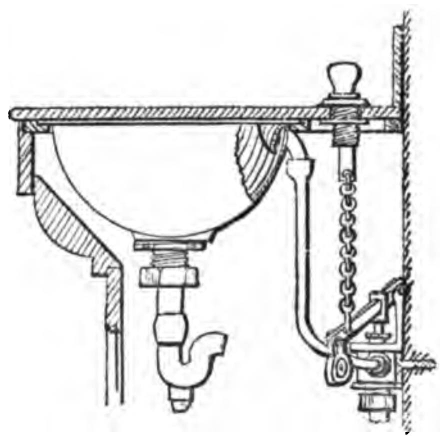

FIG. 576.

common practice is to botch the defect with paint and red lead cement, and this has to be re-done from time to time as the movement of the pipes, caused by changes of temperature, destroys the soundness of the connection.

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Another method, which, although superior to the latter, is not really good, is to have a special made nozzle, connected to the supply valves by means of a breeches piece, to discharge over the top edge of the basin, a piece being notched out of the under side of the marble or slate top to fit over the nozzle. In some instances, the latter has been connected to the top similarly to that shown by Fig. 572, a "crane-neck" being substituted for the cock shown in the illustration. Sometimes the crane-neck standard is connected to the hot and cold water valves, when the latter are fixed or embedded in the wall at the back of the basin, but this is not to be commended in any way, for the reason that the plastered walls have to be cut away for renewing the cocks or become broken by the movement of that supplying hot water. Defective or leaking cocks will also render the walls, under the above conditions, into a damp condition with the usual ill appearances.

Taken altogether we may accept the standard cocks and their fitting up as shown by Figs. 570 to 574 to be the best until further improvements have be made in their arrangement and construction, which no doubt will eventually be the case.

The cold water supply to wash basins, especially when they are fixed in lavatories and dressing-rooms, should not be drawn from any contaminated source, such as a W.C. cistern. This applies more especially when the supply cocks are fixed over the wash basins, or in positions where the water can be drawn into a tumbler or drinking cup. In some lavatories a water bottle, supposed to be filled with clean water, and a tumbler are provided, but as the bottle is generally charged from the taps over the basins it is important that the supply should be drawn from a pure source.

Lavatory basins and urinal basins are often found fixed in combination. That is, a wash basin is fixed on the top, and an urinal basin inside the same enclosure, and the same waste pipe made to answer for the two fittings. We need not enter fully into the details, but simply dismiss the subject by saying that in practice such arrangements are found to be very unsanitary and frequently in a filthy condition.

Other wash basins made to fold on a hinge at the back into an opening, or onto the face, of a wall, are often found in offices and such places where space is limited. Although compact and unobtrusive in appearance when closed, they cannot be accepted as being sanitary or free from objectionable smells. Neither can any such conveniences be considered as desirable neighbours in an office in which a considerable portion of one's time is spent, especially bearing in mind the experiences which crop up of their being used as urinals, as well as wash basins.

By some considered as a luxury, and by others as a necessity, is a shampooing apparatus. There are various kinds of such fittings, and we will refer to two or three of them. Fig. 577 is an illustration of a three-way cock attached to a bracket, with a boss for fixing to the wall. Behind the boss are two unions, to which are attached the pipes for supplying hot and cold water. The perforations in the key of the cock are so arranged that by turning the lever handle hot or cold water escapes out of the bottom at G, whence it is conveyed by

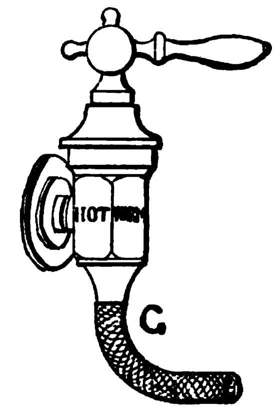

FIG. 577.

means of a flexible tube or small hose pipe to a rose, to be held in the hand, for use in the desired positions. By a careful adjustment of the lever handle a mixture of hot and cold water, at the desired temperature, can be drawn. In the apparatus described there is no provision made for showing the temperature of the escaping water. In use it is found that by holding the back of the hand, or the wrist, under the water the heat can be ascertained if comfortable for application to the head or other part being shampooed. Care, however, should be taken, when it is desired to change the heat of the water during the operation, that the mistake should not be made of turning on the hot water so as to scald the person's head or body. It is always advisable to have an attendant to manipulate the cock. If the user attempts to do this himself he may unwittingly turn the handle the wrong way and thus injure himself. The hose pipe is usually made of vulcanised indiarubber, and covered with worsted plaited on similar to the outer covering of a whip thong. For best work the plaiting is done with fancy coloured silks instead of worsted. To prevent the ravelling of the ends of the plaiting, and also to make a smart looking finish to the connection to the unions, a metal cap is fitted on as shown, partly in elevation and partly in section, at H, Fig. 578. The indiarubber tubing should be of good quality and a fair thickness, otherwise it will kink so as to prevent the water escaping and eventually crack and leak at the kink. When plain, uncovered thin tubing has been used, and the water could not freely escape at the rose, the

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pressure has been found sufficient to burst the tubing or, under a low pressure, to blow it out like a balloon, hence the necessity of the above advice. The rose is best when made of vulcanite or ebonite. When brass, or copper,

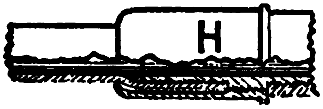

FIG. 578.

either plain or nickel plated, is used, the weight in falling will sometimes break the earthenware basin. The rose should have a shank, as shown at I, Fig. 579, for holding in the hand, and it is an advantage for this to be made rough, or other provision made for enabling the user, whose hands may be slippery by being covered with soap, to have a firm grip. The rose should not exceed 2½ in. measured across

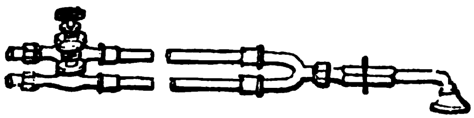

FIG. 579.

the face, and the perforations should be as tiny as possible so that the water may issue n very fine sprays.

Another arrangement for shampooing is shown by Fig. 579. This is not quite so convenient as the other, and the weight of the double tube, between the cocks and rose, and also the metal breeches piece makes the whole heavy and cumbersome. With this fitting the tube lasts but a very short time owing to the strain upon it when being used.

The illustration, Fig. 580, shows a very good apparatus which is rigidly fixed to the wash

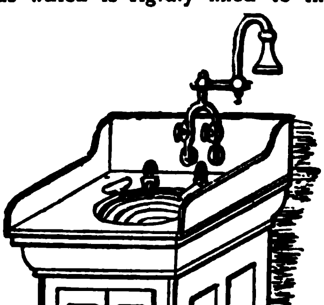

FIG. 580.

basin marble work. This can be as shown in the figure or the breeches piece can be screwed to the top instead of the skirting. The latter is preferable in cases where the enclosure is fixed close to the wall and there would be some difficulty in getting at the connections if arranged as shown in the figure. The swan neck has joints fitted so that the crane can be pushed back out of the way, turned sideways for the water to play on the side of the head, or reversed for the water to escape upwards onto the face when the person is stooping over it. The whole arrangement is very compact and can be used without any assistance. Many similar fittings are met with in mansions, but the writer has never seen one with a thermometer attached. He considers there should be some means of knowing the heat of the water, and in works over which he has had control has advised such an instrument. This has been referred to before and the principle illustrated in Fig. 548. In Fig. 580, the shampoo fitting is shown as being complete in itself and under the assumption that the basin is filled by means of separate valves. There are combination valves made for answering the double purpose, but their use cannot be recommended owing to their complication. Having a great many working parts, one or other of them need frequent repairs. When the hot and cold water supply cisterns are at different levels there is some little care required in the manipulation of the valves to a shampooing apparatus. The valve which is in connection with the highest cistern should not be opened so wide as the other. The higher pressure water will so fill the crane neck leading to the rose that the lower pressure water cannot escape.

Some shampooing apparati are made to shut off the water by simply pushing back the crane. When such fittings are used with hot and cold water supply attachments the valves should be closed before pushing back the crane, otherwise the hot or cold water, whichever is drawn from the highest cistern, will flow from one to the other.

At this point we may deal with a few illustrations of wash basins fixed in an improper manner. This is with a view to preventing blunders, that have been discovered in practice, from being repeated. The examples will be taken at random, as they come to memory. At a large house in London a wash basin fixed in lavatory adjoining a class-room on the top floor of a young ladies' school had no trap on the waste-pipe. The latter discharged onto a lead roof outside, as shown by Fig. 581, the waste water spread about on the roof, leaving an ill-smelling deposit behind. The greater portion consisted of black slime, and at the time of inspection this had a zig-zag track washed through it by the later discharges, the soap curds in which were almost white, but would doubtless have turned to the colour of the other portion after an elapse of a short space of time. Disinfectants had been thrown from the window on to this because of the offensive odours. From the roof the water trickled down the rain water pipe at J, the inside of which was thickly coated with slime with

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which was mixed other offensive matters. The rain water pipe was made of iron, the joints being left unmade, and passed down outside the house to the ground-floor. The basement was roofed over and used as a dining-room, the above rain water pipe with open joints passing through this room with nothing to prevent the escape of smells, excepting a wooden casing, which was far from being air-tight. The pipe had a trap at the bottom, but this was cemented over. So that, as the bottom end of the pipe was not open to the air, it could not be accepted as being properly disconnected from the drains, or in a condition that could be called sanitary. The small lead roof shown in the figure is over a tier of W.C.'s, the soil ventilating pipe, K, being only 6 ft. away from and level with the windows of the top floor rooms. The recommendations given for improving matters were (*a*) continue the soil vent pipe across the small lead roof and thence to the ridge of the main roof; (*b*) fix a trap to the W.H.B. with an 1¼ in. ventilating pipe to the roof and a new 1½ in. lead waste pipe from the basin trap to an intercepting trap fixed in an outside area, and (*c*) substitute a lead pipe with

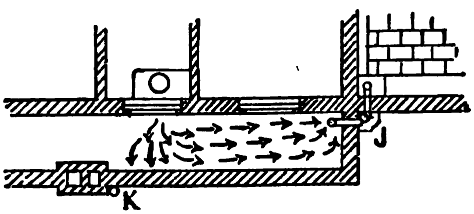

FIG. 581.

wiped soldered joints for the iron one fixed through the dining-room, and lay a drain from the bottom end to an intercepting trap as described for the wash basin.

Another case, taking from a house in St. John's Wood, is illustrated by Fig. 582, which shows an untrapped waste pipe from a W.H.B. discharging onto the lead roof of a porch over the front doorway. In addition to the accumulation of black offensive matter, as described in the last case, the lead roof was cracked across by the effects of the hot water from the basin expanding the lead which contracted on cooling, the alternate motions causing the metal to rise in buckles and eventually to break. The lead near the outlet pipe at L was also broken all round at the joint. The alterations made were a new waste pipe to a gully trap in the basement, a trap under the basin and a vent pipe to the open air.

Fig. 583 is a plan of a portion of the apartments of the secretary of a large institution, the upper floor of which he and his family and servants occupied. The sink M, fitted in the scullery, had a good trap and ventilation pipe from it to the roof, the waste pipe, N, was fixed outside the house to the basement and there connected directly to the drain and was not disconnected in any way, so that it was actually acting as a drain ventilator. The wash basin O, fixed by the side of the secretary's own bedstead, had a fairly good trap, nickel plated, and made of cast brass, the waste from which was connected to that from the sink as shown in the

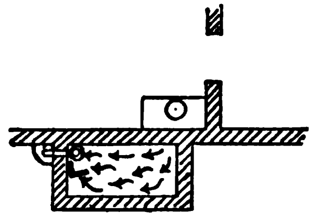

FIG. 582.

figure. As there was no provision on the trap for attaching a vent pipe none was fixed, with the result that every time any water was emptied down the sink the basin trap was partially emptied and the water seal broken by syphonage. When in this condition, there is nothing to prevent air directly from the drains filling the bedroom. This, and several other defects in the building, has not yet been altered, the plea being that the remedies were so expensive that they could not be afforded. On the advice being tendered that the basin should be entirely removed, as being both unsanitary and unsuitably placed, the reply was, "Can't do that, only recently paid several pounds to have it fixed." There is little room for doubting that sooner or later serious consequences will follow this obstinacy in retaining a known evil.

Some few months ago, when making a sanitary survey of a country mansion in Sussex, it was necessary to spend a few days over it. Having occasion to go into the billiard-room

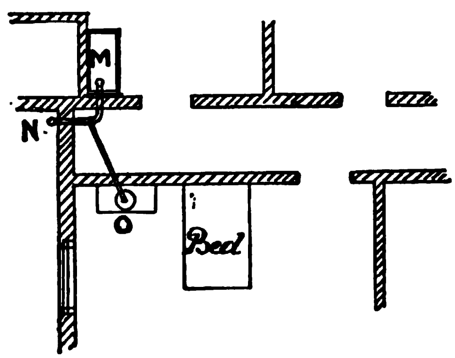

FIG. 583.

lavatory, at the hotel where he was staying, to use a wash basin, the writer noticed the same odour that is almost a daily experience when examining unsanitary houses. Although it was not his business he could not resist the feeling of curiosity to know why this was so, especially as the whole fitting appeared to have only

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recently been fixed. The basins being unenclosed the whole of the pipes could be seen by simply stooping to look beneath. Fig. 584 is an illustration of what he saw. Each of the two basins had an 1¼ in. lead anti-D trap and an 1¼ in. lead branch into a 2 in. horizontal waste pipe. To each basin an 1¼ in. overflow pipe was fixed and branched into the 2 in. main waste. As these latter pipes were not trapped in any way, bad air escaped out of each of them as shown by the darts, and thus did away with the protection supposed to be afforded by the traps on the waste pipes. The joints were well made and the whole of the work was apparently done by a man who had skilled hands but was wanting in brain power. This was further proved by the way the 2 in. horizontal pipe was continued through the wall as shown at P and the square connections of the branch waste pipes. As arranged, some portion of the waste water flows to the left when the basins are emptied, and there is not the least doubt that eventually the vent pipe will become useless through an accumulation of soapy matter at Q. The white veined marble top was entirely spoilt and disfigured by being bedded onto the basins with white lead, the oil from which had penetrated the marble and shown through on the upper surface. The remarks made in earlier lectures will apply to the alterations that should be made to improve the existing conditions of the pipes, but with regard to the marble, it would be cheaper to have a new top than to endeavour to extract the oil out of the present one.

Serious complaints of the existence of bad smells in a house in North Lincolnshire led to the writer going down to find the cause. The smells pervaded the whole of the rooms, on the ground floor, which had boarded floors. Where they were paved and had stone floors the rooms

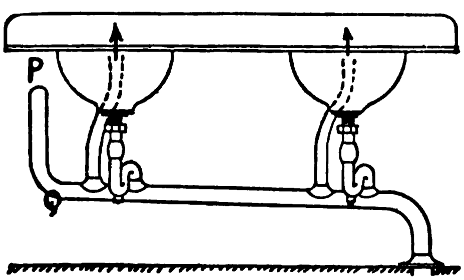

FIG. 584.

were free from smells. A board having been taken up the earth beneath was found to be saturated with sewage and beneath the W.C. and washbasin there was a large pool. Fig. 585 is an illustration of how the waste pipe, which was the cause of the trouble, had been arranged. The D trap under the W.C. had evidently been kept down to the drain level so as to avoid the trouble of making a bent lead connection, which would have been necessary if the trap had been fixed close to the W.C apparatus. The waste pipe from the basin was branched into the long dip pipe of the trap and had, by its pulling and thrusting, caused by hot water passing through, broken away as shown by the figure. In addition to a considerable portion of the waste water passing

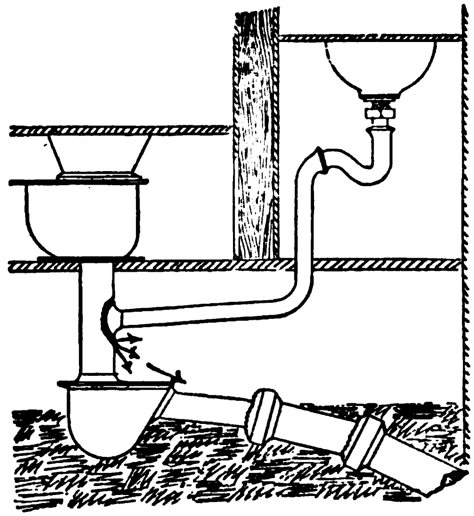

FIG. 585.

through the aperture a large quantity of W.C. matter also escaped whenever that fitting was used. Another defective detail was the absence of a ventilating pipe to the W.H.B. trap.

An example of a serious evil, which primarily arose from bad design and construction, is shown by Fig. 586, and is taken from one of several lavatories similarly fitted up in a large block of offices in Victoria-street, Westminster.

Each suite of offices has a W.C. wash basin, with a small sink and draw-off cock beneath and a cistern as shown in the sketch. The D trap, R, is fixed beneath the flooring, and to this trap the waste pipes from the sink and wash basin are attached. In the case under consideration the screw cap in the D trap had been removed, and the whole of the waste water escaped into the cistern which supplied the fittings on the floor below. Complaints having been made by the tenants of the lower floor of the cloudy appearance of the water they were using, not only for sanitary purposes, but also for drinking, and also of the unpleasant odour of the water, an examination was made, which resulted in the above discovery. The trap was found to be lined with black slime, and the waste from it choked with similar matter. There is not the least doubt that on finding the pipe in that condition the workman went away for some appliances for removing the obstruction, and was probably sent to other work and the whole affair forgotten. If the trap had been of

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a more self-cleaning shape and fixed above the floor, or where it was accessible without troubling the people on the floor below, the above would not have happened. Another evil in connection with this was the adjoining W.C., which had no safe under it. Any leakage or overflow from the W.C. would pass through the floor and fall into the cistern below. On this it may be added that, through faulty construction and defective work, numbers of people

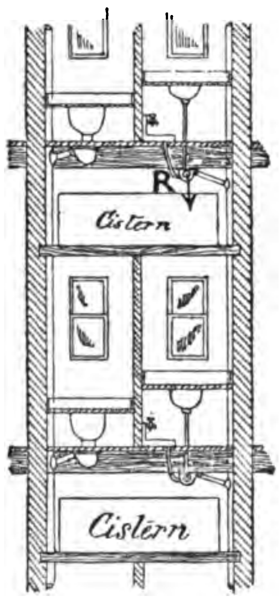

FIG. 586.

frequently drink water which has been polluted, and which, not to mince matters, may be described as diluted sewage. And this is found in the houses of the wealthy as much as in those of a lower grade in society. We may have further to say on water contamination at a future time.

A very unsanitary arrangement of a wash-basin, examples of which are frequently met with in town and country mansions, and also in offices, is shown by Fig. 587. A wash basin, fixed in the same compartment as the W.C., with the waste pipe attached to the W.C. trap. Cases have been met with where the connection was above the water line in the trap, so that the air from the drains escaped through the wash basin. Even when the waste pipe is properly (?) branched into the trap it cannot be accepted as being sanitary. In most cases the horizontal portion is wholly or partially filled with a liquid in all respects similar to that in the trap, and the odours from this can only escape through the plug hole or overflow pipe in the basin. Even when the pipe referred to does drain empty a portion of the contents of the trap are forced into it at each usage of the W.C., and at the same time a puff of bad air is driven out of the wash basin. In the illustration the old "pan closet" and "D trap" are

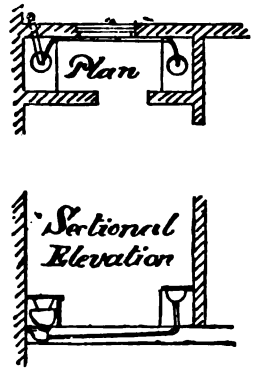

FIG. 587.

shown, as the combination with the wash basin is frequently found. In a seaside boarding house where the writer spent his summer holiday in 1893, the conveniences were as illustrated above, although the house had not been built more than two years. And there is every reason to suppose that in other places similar arrangements are being carried out at the present time. Some little time ago the writer's attention was drawn to the sanitary arrangements of a new building in course of construction, and was very interested in the way the

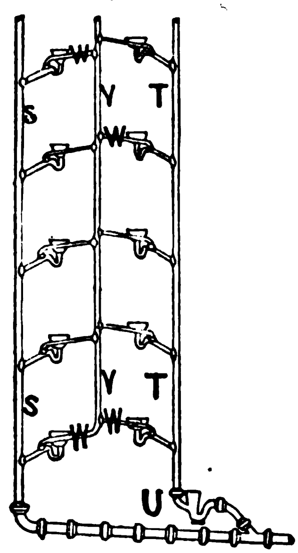

FIG. 588.

ventilation of the traps under the W.C.'s and wash basins was being effected. The building was a very high one, and in one wing a tier of W.C.'s, with branches connected to a main stack of soil pipe, and a tier of wash basins,

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with branches connected to a main stack of waste pipe, were fixed as shown in the diagram, Fig. 588. The soil pipe S S was fixed outside the building and connected directly to the drain. The waste pipe T T was also fixed externally, and the bottom end emptied into an intercepting trap, as shown at U. A stack of ventilating pipe, as shown at V V was fixed about midway between the other two pipes, and to this was joined all the branch vent pipes, W W, from the traps under the W.C.'s and basins. As the main stack of vent pipe was only 2 in. diameter, there is not the least doubt that the usage of any of the W.C.'s would affect the traps of the others, and also those under the wash basins. Irrespective of this the arrangement was far from being in unison with modern English ideas on the subject in that the waste pipes were charged with air from the drains, and this air could escape out of the end of the pipe at U. By reason of the by-pass formed by the connection of the trap vent pipes the intercepting trap was rendered perfectly useless. The proper remedy in this case would be to fix separate stacks of vent pipes from each tier of fittings.

In the lectures on setting out plumbers' work were given illustrations, see Figs. 102 and 103, showing the trapping arrangements with the waste and ventilating pipes. Another example is shown by Fig. 564. In each case a trap is shown to every basin. By some this is considered to be an extravagance, but by the writer it is looked upon as a necessity. And this quite as much as having one under each W.C. The centre basin in Fig. 103 has a trap, O, which has a deeper water seal than the others. Although not usually carried out in practice, and neither is it desirable to do so, yet there are cases where a deep one is an advantage. In houses occupied during only certain seasons, and when only a few servants are living in them, the fittings are often unused for several weeks, or probably months, at a time. In the intervals all the water may have evaporated out of the traps, and this is especially so when they are exposed and the surrounding air is warm, or a brisk air current passes them. Under these conditions those with deeper seals will take longer to empty by evaporation, and consequently the air from the fouled waste pipe, and which has probably passed over the stagnant contents of a bad form of gully trap, is less liable to enter the house.

Referring to Fig. 564, a branch vent pipe C is shown with the end passing through the wall to the open air. It has been urged that with a single basin this is quite unnecessary, but in practice it has been found to be of importance, for the reason that without it the seal of the trap cannot be maintained intact. With hollow bowls there is little or no after-dribble, after being emptied, to replace the water syphoned out of the trap. With some baths and flat bottomed sinks sufficient water will slowly drain into them to recharge them after the above action has been exhausted, but not so with wash basins. Hence the necessity for ventilating the trap of even a single basin. With a combination of W.H.B.'s the necessity is increased. For the reasons the chapters on soil pipes and W.C. trap ventilation should be re-read. The sizes of these pipes should be governed by the same rules as were laid down in the above chapters. Traps without water are useless, and without such pipes they would frequently be found empty.

In Fig. 564 the vent pipe C is continued through the wall, and this is the proper method to adopt. It will be noticed that the outer end is about level with the top of the basin. If fixed lower, at times there would be a small spray of water ejected when the basin was emptied. The branch joint to the trap is shown as it should be arranged. Sometimes this is made on the top, in which cases soapy water washes up, and by a continuous deposit of thin films eventually entirely chokes the end of the vent pipe. Another reason is a current of air through the waste and vent pipes does not pass immediately over the water in the trap, and hence little or no evaporation can take place by its action.

In Fig. 103 the waste pipe is shown inside the building and the trap vents carried through the wall. There is no great harm in this, excepting when the latter pipes discharge into a light and air shaft in the middle of a building, or group of buildings, when the vents should be continued to the roof. Other examples of ventilation are illustrated by Figs. 102 and 105, and a great many of the points dealt with in the chapter on baths will apply also to the fittings under discussion.

In the elevation Fig. 102, the overflow pipes from the basins are shown as branched into the traps below the water line, and in the accompanying text it was stated that "there are objections to this." On this it must be plainly admitted that no matter how an overflow may be arranged there are objectionable points. As shown in the figure referred to, the bottom ends of the pipes are always filled with water charged with soapy matter, and this never gets thoroughly washed away. The air inside the upper portion of the pipe is stagnant, and little puffs are driven out of the arm into the basin when the latter is emptied. The overflow pipe should be branched into the trap an inch or two above the water in it, and the connection with the basin should have an opening at the top where a mop or small brush can be pushed down to clean the inside from any accumulation of filth. Reference has been made before to this detail, and also to combined waste and overflow arrangements, the latter being inside the basin and easy of removal for cleaning or disinfecting.

In Fig. 564 the waste pipe is shown as emptying through a connecting arm into a drain

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interceptor. And this the writer considers the proper arrangement, although numbers of authorities disagree with this and specify such pipes to empty *over* the gratings of the drain traps. The reasons for the writer's contention are many, based on several years' experiences, and have been given before, see the text accompanying Figs. 244 to 257 inclusive, and also to Figs. 213 and 214. When writing on baths reference was made to waste pipes emptying into channels leading into gully or intercepting traps. Some engineers arrange those from wash basins to discharge in a similar way, but the writer considers this not nearly so good as shown by Fig. 564, not only for scouring the trap and drain as clean as possible under the circumstances, but for the reasons above referred to, and which it is not necessary to repeat.

A great many plumbers and engineers discharge the waste pipes from basins fixed on upper floors of houses into large open hopper heads outside, and frequently make connections to the rain water pipes. When describing baths and their waste pipes the writer protested against the above practice, and the sharp frosts of the last winter have provided the strongest of evidence that he is right in his principles. He also feels convinced that all readers of this would endorse his views if they had seen the hundreds of cases which he has where dirty water from basins, sinks, &c., was running down the outsides of houses. Freezing as it fell the water, converted into ice, literally covered several superficial square yards of walling. In several houses in Kensington, let out in flats, the icicles extended from the ground to the top floors of five and six storied buildings, and formed grand object lessons for the student plumber or sanitary engineer. So much has been written on the above points in prior lectures on baths, &c., which apply also to wash basins, that we need not dwell longer upon them.

SINKS.

In dealing with this detail we had better commence with those made by plumbers, which consist of wooden cases lined with lead. The usual practice is first to cut and dish the waste hole and also sinkings at the angles on the top edges, so that the soldering may be flush at those parts, and then to cut out the lead to fit the case and solder the angles. When lined with one piece the lead is first dressed out, using a flapper, which was illustrated by Figs. 313 and 402, to take out all bruises and irregularities. The dimensions of the case are then measured with a rule, but it is much better to use a lath and mark the sizes on that. Assuming the case to be as shown by Fig. 589, and the dimensions inside as figured. First make a chalk line mark on the piece of lead

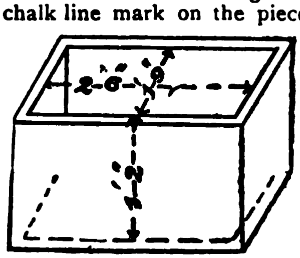

FIG. 589.

1 in. from the edge, as shown by the dotted line A A, Fig. 590, for turning over on the top of the sink. Then make another line 1½ in. from the margin, as B B, which should be square from A A, assuming that the sink has right angles. From these two lines measure the depth of the sink, which is 14 in., and mark the lines C C and D D respectively. With the lath take the length inside the casing, from this deduct a quarter of an inch to allow for the thickness of the lead, which would otherwise fit too tight, and mark the line E E. Take the width in the same manner and strike the line F F on the lead. From these last two lines make others G G and H H distant equal to the depth of the sink, namely 14 in. Cut off any lead 1½ in. beyond these latter lines as being superfluous.

We now proceed to deal with the corners. To solder up the angles the sink should be laid on its side, and to prevent the solder running through when the angles are being wiped pieces of lead should fold outside. These pieces, being about ½ in. to ⅝ in. wide, should be marked on the lead, as shown by chain lines, J J. Where the lines which are 1½ in. from the edge cut the latter small gusset pieces should be left on to mitre on the top edge of the sink, otherwise a gap of uncovered wood would be visible. The lead now to be cut on the proper lines, when it will appear as shown by Fig. 591. Some plumbers will at this stage fold up the sides and drop the lead into the case and then soil and shave the angles, ready for soldering. But the easiest and best way is to soil and shave the lead when it is laid out flat, as shown in the figure, on which the dark shaded parts

represent the soiling and the white parts the shaving, which is about 1 in. to $1\frac{1}{4}$ in. wide, according to the strength intended. After thus far preparing it, the point of a sharp shave-hook is run over the dotted lines, the sides are folded up and the bottom creased all round inside and made straight outside with a clean, smooth-edged box dresser. The small pieces having been scored, as above stated, to be gently folded round to form overcloaks on the

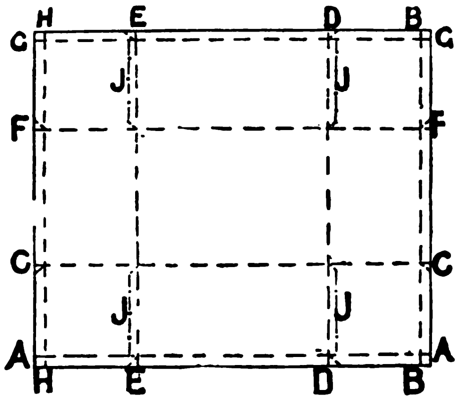

FIG. 590.

upright angles. The lead to be now laid on its side and the bottom and sides and ends made hollow on the outside by hitting them with the palm of the hand, this not disfiguring the lead, as would be the case if tools were used. The lead to be now lifted into the wooden case, when it will slip down into its proper position. Should it, however, fit too tightly and not slip down, by alternately lifting each end of the case and allowing it to drop onto the floor, or bench, the lead will shake down to the bottom. The sides being gently pressed back to their position, a piece of clean board laid on the so-called bellying, the lead bottom can be pressed down, thus forcing the latter into its position and the angles tightly home. A clean flapper used on the sides, ends, and bottom to dress down any hollows or bumps, and a clean, smooth dresser, or a large chase wedge with a thin edge, to be used to ensure the lead fitting tightly in the upright angles. Some plumbers would now drive clout nails into the latter, but it is much better to do without them and simply use a punch or a very blunt steel chisel to indent the lead in the angles to be soldered to form a kind of key to prevent the lap opening so that the solder could get behind. A nail can be partly driven in each angle about 2 in. from the top, to be afterwards taken out, to prevent the lead rising when the top edge is being worked over. The latter should now be done and the inside worked up to a straight but not too sharp arris, and the gusset pieces at the angles worked into the dishings that were cut before the lining commenced. Examination now to be made if any of the shaved parts have become tarnished, and all dull places, if any, reshaved, at the same time any scratches on the soiled parts to be resoiled. After seeing that the latter is perfectly dry, a piece of touch to be lightly rubbed over the shaved parts and for an inch or two on the soiling. The latter is to prevent the solder sticking. The sink now to be laid on its side on wood blocks about 3 in. thick on a bench, as shown by Fig. 592. The blocks are necessary for keeping the sink clear of the bench so that the plumber has no difficulty in wiping the top edge at the angles. A wiping cloth, made of so-called moleskin or fustian, having about ten thicknesses and measuring about 3 in. each way, is a good size, and fairly well "touched" on the wiping side, should be laid near the plumber's fire to be warmed ready for using. The solder being properly heated, which can be ascertained by holding the back of the hand over a ladleful, and skimmed from dross, and a plumber's iron heated to redness and filed free from scales; all being ready, the plumber then takes a ladleful, the ladle holding about 4 lbs., and proceeds to splash, by means of a stick shaped like a miniature paddle, or pour by means of a stick, as shown by Fig. 406, the solder onto the angle. In a sink the depth of the one in our problem, about two ladlesful, or about 6 lbs. or 7 lbs. in all, would be necessary to get up a heat as it is called. If the angle shown in the figure is being wiped the plumber would now take the heated iron in his left hand and the cloth in his right. The ball of the iron being moved backwards and forwards in the solder which is constantly being pushed back into the angle, from which some portion will flow in a liquid condition, until the whole is in a pasty condition. The plumber will then begin from the bottom

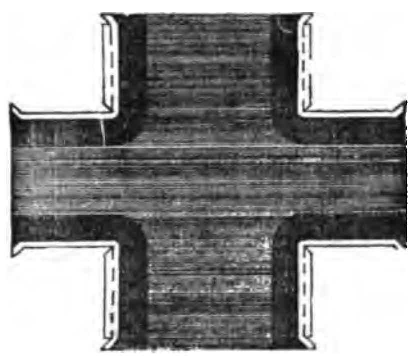

FIG 591.

end and will probably have to make two or three short wipes before he can get away, owing to a small quantity being left in the angles at K. When free from the start the plumber will then complete the angle by giving one long wipe to the front edge, and then with a short downward stroke finish the part at L.

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To make a clean, smart looking job the above instructions must be strictly followed. If the angle is soldered by wiping 3 in. or 4 in. at a time it always looks dirty and uneven at the edges. The latter is aggravated when the plumber is too long over his work, and the lead gets so expanded by being heated as to bulge out on both sides of the soldering, so that he has not straight surfaces to guide the cloth. And again, if the plumber loses his heat, as it

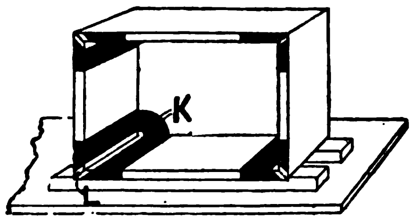

FIG. 592.

is called, the solder will set at the edges, injure his cloth by tearing it, and so spoil the soiling that it will have to be redone. If he has not been careful in using the iron he will probably have so scratched the soiling that the solder will "tin" to the exposed lead and, on setting, become troublesome to remove or detach. When the wiping is done quickly, as above advised, these evils are avoided. In this, as in joint wiping, half an hour's practice is worth more than several devoted to thought or study of the matter.

When he has finished one angle the plumber will then proceed to solder the other, the sink still being in the same position, but will hold the iron in his right hand and wipe with the left. When the solder has sufficiently set, so as to bear movement without cracking, the sink to be laid on its other side and the other two angles wiped as before. On completion, the lead to be gently flapped quite smooth, the top edge to be straightened if it has been injured by being moved about, and the outer edge planed quite straight and true and close to the woodwork of the case. The plane used by the plumber is the size of an ordinary Jack-plane, as used by carpenters, but has a steel face. Some men will prefer the "iron" more upright and not so raking as in ordinary Jack-planes, but I prefer the latter. The lead to be nailed on the top edge by means of copper nails about 2 in. or 3 in. apart. Although the nails should be of a good size it does not follow that they should be so large as to split the woodwork into which they are driven.

The top edge of a lead-lined sink does not always have the thought bestowed upon it that it should have. For instance, how rare it is to find the lead in good condition. By constantly lifting pails, cans, tubs, &c., in and out of the sink the lead gets knocked out of shape and dragged inwards, as shown by fragmentary section M, Fig. 593. To prevent this the lead is sometimes dressed down for an inch or two outside, as shown in section by N. Some plumbers will have the woodwork dished, the lead dressed into the hollow, shaved and nailed and then filled up flush with solder, as shown at O. It is a much better plan and makes a neater finish to have a capping as shown at P. This being made of oak for butlers' pantrys or china rooms, but of copper or galvanised wrought iron for scullery and still room sinks. In cases where the sinks are enclosed and have cupboards beneath them, which is not at all a sanitary arrangement, owing to the improper uses to which the latter are put, it then becomes necessary for the capping to cover the top edge of the front of the sink, and also the enclosure, as shown at Q. This prevents water passing between the two. For the sake of neatness the screw heads can be countersunk very deep and the holes filled with wood plugs to match the capping as shown in the figure.

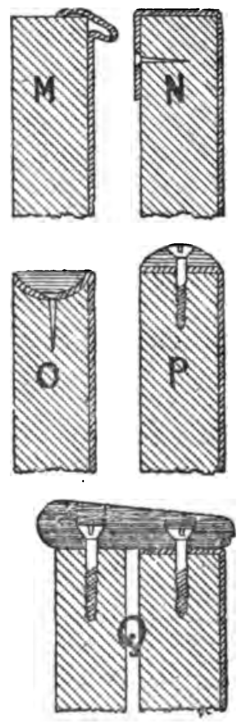

FIG. 593.

Sometimes sinks are lined by cutting out the lead to fit the bottom and two sides and putting the ends in separately, as described when writing on cistern lining, and illustrated by Figs. 408 and 409. Or line the sides and ends, and then put in the bottom as illustrated by Figs. 403 and 404. When the latter is done heavier lead is used for the bottom as that part has to resist the wear and tear of pails, tubs and

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such utensils. As the front part of the sink is subjected to hard or rough usage some plumbers will line the bottom and front with heavy lead, and the back and two ends with lighter. For example, they will use 8 lbs. or 10 lbs. lead for the former, and 6 lbs. or 7 lbs. for the latter. On this it may be stated that the amount of lead used in a sink is so small that the economy is not worth considering, and lead of equal thickness should be used throughout.

Although the usual ways for lining sinks have been described, it does not follow that they are the best. In almost every sink a quantity of hot water is used and the result is, that if not free to expand and contract, the lead will buckle and break. Because of this scullery and pantry sinks always present a wretched appearance. Fig. 594 is a section of such a case, showing the buckles at A A, and the angle soldering dragged out of its position at B B. When complaints are made of the leakage which follows, the plumber will dress down the buckles and solder patches over them. These repairs last only for a short time,

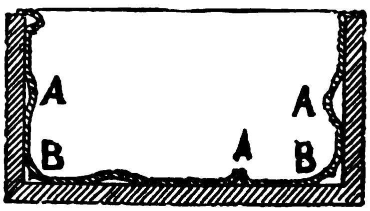

FIG. 594.

as the lead will soon break again by the sides of the parts repaired. When the cracks are opened, the woodwork beneath dished, the lead dressed into the dishing and then soldered and wiped flush with the bottom, the work looks much neater, and the water can flow to the outlet much better, but the lead will be found to break again close to the soldering. The whole principle is bad, and neither the quality of the materials used, nor the skill of the plumber, can attain a satisfactory result that shall be permanent.

By far the best method for lining sinks with lead is to boss up the corners and have hollowed fillets and sloping sides, similar to a washing tray, as shown in section by Fig. 595. The lead is not tied and is free to move by expansion, or its opposite. This has been tried in practice and found to be satisfactory. It is also an advantage to leave the top edge of the lead free, so that the above forces can have free play. This can be done as shown at C, where the top edge is let into a groove in the capping instead of being turned over on the rim of the sink. Another point is to have the waste outlet in the centre of the bottom instead of closed to a corner as usually practised. Where the sink has a plugged outlet, this latter is inconvenient, owing to the difficulty of getting out the plug when the sink is filled with crockery. The hollowed angles are a further advantage, in that they are easily accessible with a scrubbing brush and

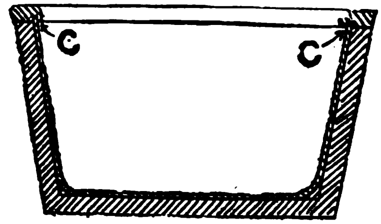

FIG. 595.

cannot retain a quantity of grease and other offensive matter.

A frequent cause for complaint of smells near sinks is found to be the amount of filth that accumulates behind and beneath them. This is found to arise from what is splashed over the top, and the best plan to prevent this is to have the sides against the walls much higher than the others, as shown by Fig. 596, which represents a double scullery sink fixed on cantilevers cut and pinned into the back wall. When lining these sinks with lead the material should be cut out as if for two sinks, but the dimensions must be varied to suit the depth of the sides. When lined separately, a soldered seam is necessary up the back side, over the division, as shown by dotted lines, and it is usual to continue the soldering on

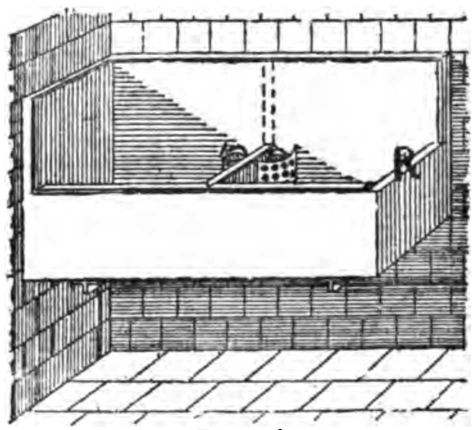

FIG. 596.

the top edge of the division. The seams should be wiped flush, and the woodwork beneath dished to a hollow for dressing the edges of the lead into, otherwise a neat job would not be made. To allow for expansion, the edges of the lead are sometimes welted instead of being soldered, but when done the job appears to be a bungled affair. In some cases the edges of the lead are butted together and a wood or metal capping screwed over the

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joining. This capping is also fixed on all the edges of the sinks, as described when writing on that detail, and illustrated by Fig. 593, not only for protecting them, but to give a neat looking finish. As a draining board, to which we shall refer further on, is usually fixed at one end of the sink, the capping at that part is omitted. In Fig. 596 this would be at R.

For high class work tinned copper lined wood sinks are fast superseding those lined with lead. The first cost of the former is a little in excess over the latter, but the outlay repays itself in a very short time. Such work is usually done by coppersmiths or metal plate workers, although plumbers sometimes undertake it. The latter tradesmen frequently do the work as if lead were used, and wipe all angles. In those parts of the country where the trades of plumbers and coppersmiths are combined various methods are practised. Sometimes the angles are wiped, and at others they are welted and then sweated with fine solder and copper-bit or blow-pipe. In a few cases the writer has seen them brazed with spelter, but only when the copper was to be left plain and not with tinned surfaces. When plumbers do the work the metal is cut out to suit the methods for joining, and if to be wiped in the angles the rules laid down for lining sinks with lead will apply.

Other kinds of Sinks.

As great complaints are made of the destruction of crockeryware when being washed, teak and other wood sinks have been much used. These are usually made similar to washing trays, the sides, ends, and bottoms being bolted together very similar to the methods adopted for making slate sinks and cisterns. Although wood is a good material to use, on account of its being softer than metals or fireclay, from a sanitary view it is not suitable for wash-up sinks on account of its porosity. After much usage the pores get filled with ill-smelling matter, and when old and partially decayed, there is the additional odour of rotten wood. When out of use for a few weeks, which is frequently the case in houses occupied by the aristocracy, wood sinks will become dry and shrink to a serious extent, although where the servants are careful, and keep a quantity of water in them this shrinkage does not

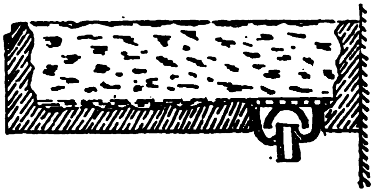

FIG. 597.

take place to such a degree. The water, however, should be frequently changed or it will become offensive.

The sinks that have been described, are what is generally known as "wash-up" sinks. That is, they are made moderately deep and have plugs over the waste pipes for retaining water in them. Where tubs are used for the above purpose it is usual to have Yorkshire stone

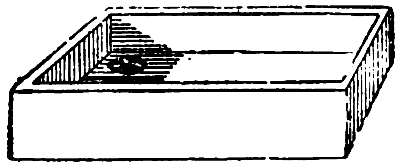

FIG. 598.

sinks. These are not at all good in that they always smell very offensive owing to the amount of filth retained in the pores. The odours that hover around them, especially when saturated with cabbage water, or that in which fish has been boiled, is quite nauseous. They also become much worn in the bottom with the iron hoops on the tubs used or from iron saucepans, buckets and such like utensils. Fig. 597, is a section of such a sink showing the irregularities in the bottom and also the grating over the waste pipe, which is not worn away to the same extent as the stone, so that the pools of water have to be swept into the grating. There are other objectionable details which we need not refer to, as such fittings are fast being superseded by others of an improved kind. Some of these are made of vitrified salt-glazed stoneware, brown in colour, and are excellent for withstanding hard wear and tear and are not at all expensive. Others have a smooth glaze of light cream colour and are also very good but a trifle higher in cost than the last.

During these last few years what is called "white enamelled fireclay sinks" have been used, and are much liked. Many forms suitable for almost any purpose are usually kept in stock by manufacturers. Fig. 598 is for kitchen use.

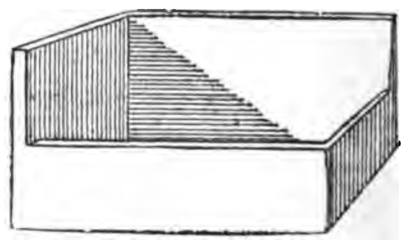

FIG. 599.

Smaller sizes are made for fixing in butlers' pantrys, china rooms, housemaids' closets and similar places, where much washing up is done and where tubs are used for holding the water and articles being cleansed, which would be injured or broken if they came in contact with the sink itself. Fig. 599 is similar to Fig. 598, but has the addition of a high back and end on the sides to be fixed near the walls. When

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sinks as Fig. 598 are fixed, the walls are usually found to be saturated with splashings. Numbers of such sinks have tiles fixed round them to prevent this, but the tiles soon tumble down owing to the material used for fixing losing its adhesive properties. Lead flashings are not at all good as water can get under the bottom edge. No matter what is done to protect the walls nothing is so effectual as having high backed sinks as above described.

Scullery Sinks.

We may now proceed to deal with the important details of fixing sinks and commence with those in the scullery. Why I call these important details, especially in connection with the scullery, is because in hundreds of cases of sanitary inspections made, when with one of our leading firms of sanitary engineers, many complaints of sore throat were made to the writer by the kitchen servants. And it really is the case that that part of the house especially retained for the preparation of food is usually found to be the most offensive smelling and in the most unsanitary condition. Judging from experiences gained in actual practice, more illness is found amongst those servants whose duty it is to prepare food for the table than amongst any other class in the same house. There may be other details which may have an effect on health, but those which are the most important are connected with the problem of getting rid of the waste matters. Before entering into particulars it may be stated that if the kitchen and scullery are not fitted up with the necessary conveniences, and in a proper manner, the servants and their clothes become saturated with evil-smelling matter which is anything but conducive to health. A blindfolded person, if led through the bedrooms of a house, by the odour alone could, in many cases, detect that in which the scullery servant slept. She may be a perfectly clean person in herself, but having to perform her duties under disadvantageous conditions, she becomes in the performance of those duties an ill-smelling nuisance to herself and everybody with whom she comes into contact.

From this we arrive at the conclusion that what may be termed the scullery plant should be ample for all purposes. In many houses the only convenience provided is a sink, as shown by Fig 597, and a few iron-bound wooden tubs standing in the sink or on ricketty stools or backless chairs. And these tubs are used for all purposes from washing dirty crockery and iron pots and saucepans to cleaning vegetables and salads. Their shape is such that, when being used, the dirty, black, greasy water is splashed over everything that is near, including the user's dress. In well-fitted sculleries wash-up and rinsing sinks, as shown by Fig. 596, and lined with tinned copper, should always be fixed, with a plate and dish rack behind so that the drippings from the crockery can fall into the sink. When the rack is some distance away the floor between it and the sink is very much wetted. In some cases it is necessary to have a gutter and waste pipe under the rack, but this should not be fixed unless it is an actual necessity. A large size sink, as shown by Fig. 599, is required for standing saucepans in and for scouring copper cooking utensils. In large mansions two of these sinks are necessary, and also a large slate table on which to stand such utensils until it is convenient to clean them. For washing vegetables three sinks are necessary, one being for roots, a second for greens, and a third for salads. The latter on no account should be used for any other purpose. In some instances two sinks for roots are an advantage, but if the latter are well washed and all earthy matter removed before being brought into the house one sink answers the purpose fairly well. All the latter sinks should be what is called "enamelled fire clay." They are very strong, and being white inside have a clean appearance. The inside depths of the various sinks should be as follows:—Wash-up, 14 in.; vegetable, 13 in.; and scouring, 5 in. to 6 in.

All sinks should be fixed on galvanised cast-iron cantilevers, as before described and shown by Fig. 596, or more clearly still by Fig. 600.

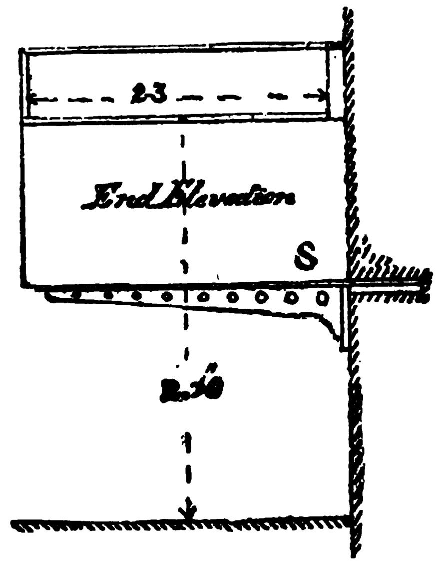

FIG. 600.

These cantilevers are now stocked by all good houses of business and are very moderate in cost. By this fixing the whole of the space beneath is clear for sweeping and cleaning, and there are no corners in which filth can accumulate and which is the case when the sinks are supported on brick piers, as usually practised. Another advantage of the clear underspace is the comfort with which the sinks can be used,

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there being nothing to kick or knock the knees against.

The height at which the sinks should be fixed has to be varied to suit the circumstances. Dealing with that for washing plates and dishes first. Assuming the user to be about 5 ft. 4 in. in height and the sink to measure 2 ft. 3 in. inside from back to front. The top edge of the front should be 2 ft. 10 in. above the floor, or 3 ft. if a 2 in. thick wooden latticework floor-rack is used for standing upon. By some the height would be considered excessive, but when fixed lower complaints are made that the person's back aches very much, especially when reaching over to find anything lying in the bottom at the point S, Fig. 600, and which is only about 1 ft. 8 in. above the floor line. The sink being 14 in. deep, after allowing 3 in. for the motion of the water when being used, 11 in. in depth will remain. This may appear to be very shallow for large establishments, but it should not be exceeded, as even with that quantity the user's arms would be immersed above the elbows when washing dishes. For medium size establishments the sinks should not be so wide as stated, and 2 ft. will be found ample. But the height should remain the same and the depth reduced by about 1 in. In small houses which have sculleries the size may be further reduced. When deciding upon dimensions for such fittings it is not at all a bad plan to consult the persons who will have to use them, and also have a look at the dinner services, as in some mansions very large pieces, or dishes, are used, and these would get jammed in the sink if it were too small.

The vegetable washers should be about 30 in. × 20 in. × 16 in. outside measurement, and fixed on cantilevers, the top edge of the sink being about 2 ft. 6 in. above the floor line. The apparent lowness of this will be explained further on.

The scouring sink should be a good large one. The largest stock size made at the present time being 48 in. × 24 in × 8½ in. outside dimensions. But no doubt that in the near future sinks will be made more suitable for extensive establishments. But with the above a good job can be made by adding a slate or other suitable top. Such sinks should not be fixed more than 2 ft. 6 in. above the floor. If higher, the servant cannot stoop over the work in hand or reach into a tub if necessary to use one. With this latter sink there is sometimes a little trouble in making the connection to the waste pipe. Many ways are practised, but the only reliable one is to have what is called a brass grated connection with fly nut and union. Those sinks which have a number of small holes in the material should be rejected, and those with plain, counter-sunk waste holes, as shown in Fig. 598, selected.

Fig. 601 is a fragmentary section of a sink showing the grated connection. It is advisable to buy this with the sink. If purchased of any other manufacturer it may not fit properly and, if too tight, may in expanding break the sink. This advice should be strictly followed as many sinks are destroyed through neglect of this apparently trivial detail. For reasons that have

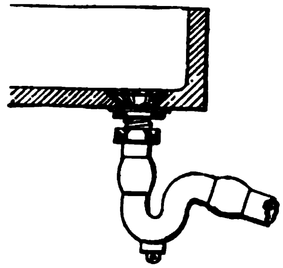

FIG. 601.

already been given, the water-way through the brasswork should be of a good size, and never less than 2 in. in diameter when a 1½ in. trap and waste pipe are fixed, or 2½ in. to 3 in. when the latter are 2 in. The extra size is to allow for obstruction, or reduction in area, caused by the grating.

For metal lined sinks it is usual to solder the trap and grating to the bottom, the woodwork being dished round the waste hole so that the joint may be below the surface. If a 2 in. trap and waste pipe are to be used the former should have what is commonly called a coned inlet. Fig. 602 clearly explains this and shows a large size grating, the perforations in which in the aggregate are as large as, or exceed, the internal cross area of the trap or waste pipe. It will be noticed that the grating is so low down that tubs or anything of that kind cannot rest upon or injure it.

When sinks are used for washing up purposes it then becomes necessary to fix plugs over the

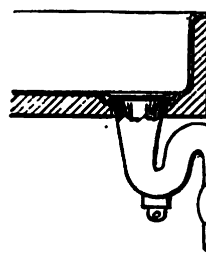

FIG. 602.

waste pipes to retain the water in them. For a fireclay or other hardware sink, this fitting would be as shown in section by Fig. 603. In this case, too, it is important that the brasswork should be below the level of the bottom, otherwise the plug may be driven into the washer so tightly that it cannot be got out. At T there should be a grating for preventing anything passing through to choke the waste pipe. So that the grating should not throttle the water-way, the washer should be large in size for reasons

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already given. For metal lined sinks the attachment should be as shown by Fig. 604, the trap having an enlarged inlet for taking the plug and washer. In the latter figure, the ring is shown recessed into the plug. This is much better than the one shown in Fig. 603. In Fig. 604 the grating is attached to the bottom of the washer, as shown in section at U. These gratings vary very much in design and some of them are of a very objectionable form, and, although 2½ in. and 3 in. in diameter, have such

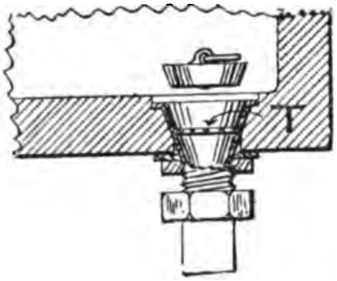

FIG. 603.

small holes that the water-way is reduced to about the area of a 1 in. or 1¼ in. pipe. The water passing through such gratings does not fill the bore of the trap and pipe, with the result that an amount of slimy matter will adhere and eventually choke them up. An improved grating shown by Fig. 605, and known as a "Cobweb grating," is far preferable on account of the small obstruction it presents to water passing through. Some plumbers and engineers have a few "crossbars" in the washer, in lieu of the grating. These consist of small brass wires passed through holes drilled in the washer to receive them, the ends being rivetted on the outside. The traps under scullery, or indeed any other sinks should always have screw caps

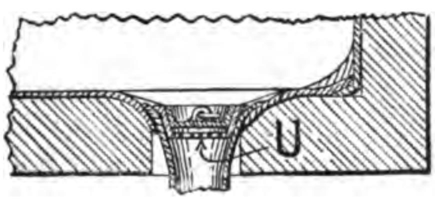

FIG. 604.

to them, as shown by Figs. 601 and 602, for the removal of anything that may get inside. It is almost impossible to guard against the traps being choked at times. Even a small fish bone may lead to a stoppage. If it should pass endways through the grating and get crossways inside the trap other matters will cling around it and eventually form a solid plug. Sand used for scouring cooking utensils, and mud and small pieces of matter, such as potato parings, are a constant source of trouble, although these will frequently pass through the waste pipe and choke the gully trap outside, especially when the latter is of a large size or an unsuitable shape.

All sinks with plugged wastes should have overflow pipes to them. And these should be of a large size with grated inlets. The previous

FIG. 605.

remarks on these latter fittings apply also in this case. The best form for the overflow gratings is shown by Fig. 606, and can be made for soldering in the end of the pipe when attached to metal lined sinks, or with screws or flanges for fastening to the holes in those made of stoneware or fireclay. Some of the latter have provisions for overflow made in the thickness of the material, and are fairly good, but the generality of them have such tiny holes as to render them almost useless. And, excepting with one or two makes, no provision is made for access for cleaning the insides when foul or filled with congealed grease. A considerable quantity of the latter floating on the top of the water in a wash-up sink will flow down the pipe and cause a stoppage. This evil, and several others in connection with our subject, would be much reduced if the servants could be

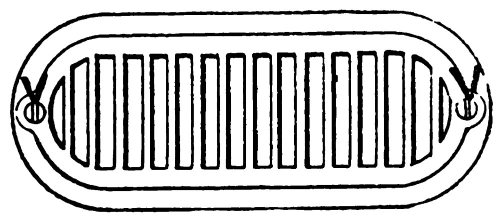

FIG. 606.

persuaded to scrape all grease and odds and ends off the plates and dishes before washing them.

On referring again to Fig. 606 it will be noticed that the grating has a rim to it. This is soldered to the metal lining of the sink, and by taking out the screws shown at V V the grating can be removed for access for passing a cane

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or small brush into the pipe, and afterwards refixed. A troublesome detail in connection with the overflow pipe is where it shall discharge. To take it into the open air is very objectionable, and if joined to the trap under the sink it will be perfectly useless if the trap becomes choked. To fix a separate trap and pipe cannot be recommended, as the former would never get thoroughly washed out or would become empty, by evaporation, if the sink was never filled to overflowing. Of all the evils that of making the connection to the trap is the least, and is the one most commonly practised.

In large establishments where of necessity the wash-up sinks must be of a good size, and the space in them can be spared, it is always advisable to have the waste holes close in the corners and strainers fixed, as shown by Fig. 596. These prevent injury to the plugs, or being jammed in by the movement of whatever is being used, and also the difficulty of getting them out when the sink is full of crockery. The strainers being of a good size, small holes are all that is necessary, and with them there is less liability of the trap and waste pipe being choked. Another advantage of this arrangement is the objectionable overflow pipe can be abandoned, and, instead of a plug, a trumpet mouthed waste pipe can be substituted. This fitting is shown by Fig. 607, which is a section of an angle of a sink with trumpet pipe, having a bow handle, W, for lifting out when desired for emptying. The dotted lines represent the strainer, behind which the stand pipe is fixed. By this arrangement the latter can be lifted out and washed and cleansed whenever it becomes foul. Hence its advantage over the overflow pipes which have been described. The strainer, being fixed by means of slips attached to the sides of the sink, into which it slides, can also taken out, scrubbed, and be replaced.

As mentioned before, all scullery wash-up sinks should have draining boards at the side, and these should be of a good size, not only for their ostensible purpose, but also to hold dirty crockeryware waiting to be washed. Such boards should have corrugated surfaces to allow the water to flow away when the articles are placed upon them to drain. Plates and dishes would be placed in a rack fixed to the wall above or near the sink, but there are several utensils that cannot be so placed, hence the necessity of the boards.

Fig 608, is a view of the combination with a high back to the board continued at the same level as that of the sink. Such an arrangement is suitable for a medium-sized house, but for larger ones with double sinks another board would be fixed at the other end. If there is no wall at the right-hand end the skirting would be omitted. The front capping of the sink would be continued on the front of the board to prevent anything slipping off. Sometimes wood only is used, but when the sink or sinks are lined with lead the board is covered with the same material and chased into the furrows of the corrugations. When copper is the material used for lining the sink it is also used for the boards. To make a neat-looking job this latter material has to be wrinkled by passing it through iron or steel rollers, and this should be done before the carpenter prepares the board, otherwise there is some trouble in making the copper fit nicely. That is, it is easier to fit the wood to the metal than *vice versa*. The dripping eave of the drainer should hang down in

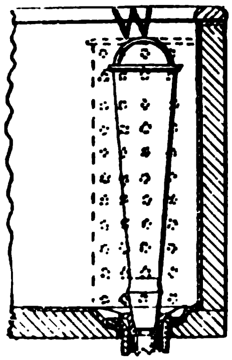

FIG. 607.

the end of the sink at least 2 in., otherwise water is drawn in by capillarity and rots the woodwork at the part marked X, in the figure.

For several years past the difficult problem of disposing of the waste water from scullery wash-up sinks, either the metal lined, or when made of hard—or stone—ware in which tubs are used, has engaged the attention of plumbers and sanitary engineers. The principal difficulty has been the grease, which, flowing in a liquid state into the drains, congeals, and eventually blocks them up. Before sanitary science was so well understood as at the present time, and when drains were made of a very large size, with no disconnecting traps in their course, so that rats could get free access to feed on what came from the scullery, less difficulty was experienced. But under modern conditions this is all changed. When smaller sized trapped drains were introduced the trouble with grease became very prominent. The first introduction was a trap especially constructed for intercepting the matter. Fig. 609, is a representation of what used to be practised and which may be found at the present time in large numbers of the houses, both in town and country, in which the higher classes of society live. These matters were referred to in my earlier writings several years ago, but repetition may be of advantage to those who have not read my book "Plumbing Practice."

The sink and bell trap were dealt with above. In many cases a drain pipe is fixed, as shown

under the sink, Fig. 609, and as there is some difficulty in making the joint, sometimes no attempt is made to do this, air from the underground cesspool trap can escape as shown by the arrows. The trap under the pavement is built with brick, the walls are rarely to be found watertight, so that sewage oozes through and saturates the earth. On taking out such traps the surroundings are almost invariably found to be black with sewage and containing large numbers of small red worms, which seem to thrive in such matter. The "dip stone" Y is perfectly useless for keeping drain air from passing, owing to the open space at Z, but effectually prevents the greater body of grease from escaping into the drain. The above material on decomposing gives off large volumes of marsh and other inflammable gases, and in some cases the writer has set fire to them, but

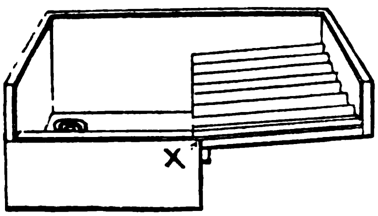

FIG. 608.

knowing the results has carefully stood on one side to avoid the explosion which sometimes follows. In some houses the traps are so large that they will go on for one or two years before becoming so full as to necessitate their being cleaned out, and in others they require attention every few months. In country mansions anyone, a gardener or a farm labourer, is set to work to remove the grease, and in town houses the dustman has sometimes been asked to take it away with the dust. When proper men are not employed to do the work the cover stone A is not properly bedded down, with the result that air not only from the drains, but also from the contents of the traps, escapes freely into the house, as shown by the darts. When inspecting houses as to their healthy condition, cases have been discovered where the sink waste pipe has been altered and made to empty into a gully trap outside the house, but the old underground trap and its foul contents have been allowed to remain. Some of these troubles are very hard to discover, especially when being assisted by a grey-haired old bricklayer, or other estate workman, who "knaws they's all right as 'e 'elped 'is old fayther to put 'm in ower forty year ago," and puts you down as being a meddling fussy body if you insist upon finding out the facts for yourself in preference to taking his statement as to the existing conditions.

Some years ago the trap shown by Fig. 221 in an earlier lecture was considered very good for preventing grease escaping into the drains, and also because air from them did not escape when the cover stone was taken off for the removal of the grease. As an improvement on the latter trap, the one shown by Fig. 261 was patented several years ago, and for a considerable time met with great favour from professional men as well as laymen. Several other forms have been introduced for catching grease, but no matter what shape they may take it must be admitted that all such traps are abominable, filthy

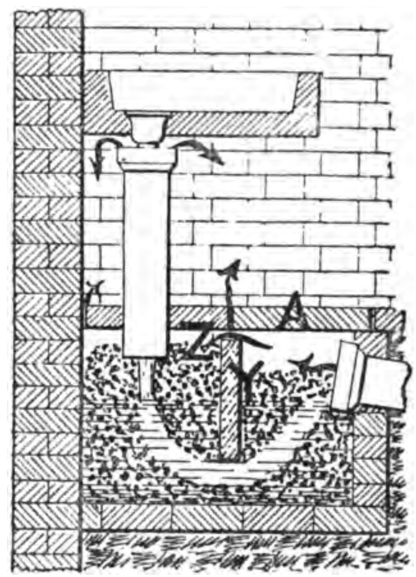

FIG. 609.

nuisances that are constantly emitting bad odours, and when being cleared of their contents poison the air for some distance away. It must also be admitted that they are neither more nor less than cesspools. The poor fellows who have to clean them out deserve commiseration, and the writer knows of men who have been ill afterwards. Large firms, who contract to do such work periodically, keep stores of disinfectants for their men to take with them when emptying some of these so-called grease interceptors and grease traps.

Old abuses die hard, and it is to be regretted that those referred to above are at the present time in hundreds of cases allowed to exist, and in fact are being reproduced. This is partly owing to the fads of the old school of plumbers and others who undertake sanitary work, and partly to the fact that other and better methods for disposing of grease are unknown excepting amongst those who undertake the highest class of work.

Amongst the earlier of the improved methods for disposing of the waste from scullery sinks was one introduced by an engineer of considerable repute, and which is shown by Fig. 610. The waste pipe was made to empty over a grating, which had a trap beneath it, fixed over a

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receiver or chamber with a syphon attached to it. When the chamber is filled to overflowing the action of the syphon is started, and the whole of the contents are quickly emptied into the drains. The action breaks up the grease, which has congealed or become partially solid, and floats it away, and at the same time the drains are fairly well flushed. The same kind

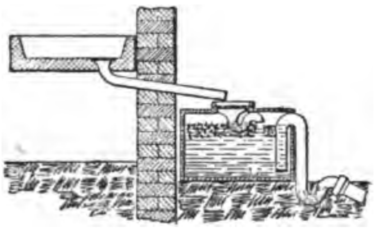

FIG. 610.

of tank has been used for catching waste water from other sinks than scullery, and also from baths. By its use all waste water is sent through the drains with a scouring force, this being better than allowing it to dribble through, in which case no cleansing force is exerted. It has been reasoned that dirty is not so good as clean water for flushing drains, also that scullery waste water becomes offensive by keeping, so that it is not advisable to have the above tanks too large.

We will now deal with one or two other methods that have been practised in later

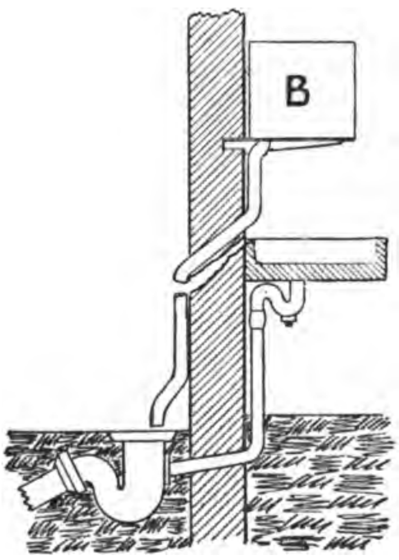

FIG. 611.

years with the object of getting rid of greasy water.

The primary object is to prevent liquid grease passing into the drains, and as it cannot easily be separated from the water when in a melted state without using special appliances or traps, constructed on the principle of that shown by Fig. 609, the first aim of plumbers and engineers at the present time is to solidify it. To do this it is passed into a gully trap, as illustrated by Fig. 611, and an automatic acting flushing tank fixed as shown at B. With the waste pipe connected to the trap on the opposite side to the outgo the combined grease and water scours through into the drain, where the former will solidify and become difficult to remove by water flushes. And as it is desired to retain the grease in the gully trap until it solidifies, it follows that the arrangement is not a good one. The flushing pipe from the cistern B, is usually made to discharge over the top of the trap, and in some instances, above the grating. When so fixed the force of the flushing water is broken and robbed of a great portion of its efficiency for scouring out the trap and drain beyond it. Although not perfect in arrangement the combination is much superior to the old cesspool trap with all its abominations.

There are several patented grease traps in the market, and a very good one, the best the

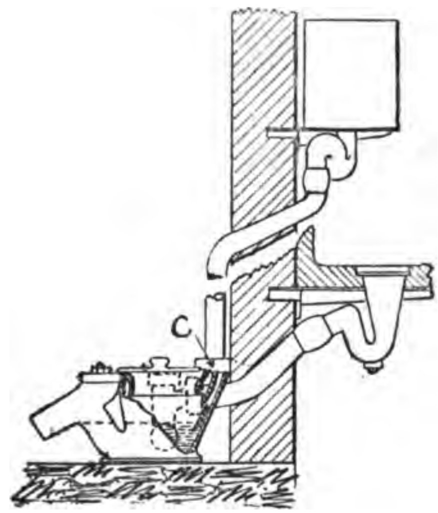

FIG. 612.

writer knows, is shown by **Fig. 612.** The trap itself has a flushing rim round the top edge with a jet opposite the outlet, and also a channel made in the material, stoneware, for another jet of water to play into the bottom to scour away sand and such matters. This stream also drives out the standing water which, no longer supporting the cake of grease, carries with it whatever is in the trap, being aided by the flush from the rim and top jet. The pipe from the tank is connected to the arm of the trap at C, and at this point is a division which separates the column of water into two portions, one going to the rim and top jet and the other to

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the bottom jet. The flushing tank should hold from 20 to 50 gallons, according to the amount of grease that passes into the trap and the length of the drain behind it; it being desirable to drive the waste matters to the outlet, either into the sewer or straining tank in connection with an irrigation scheme, if the sewage is disposed of by the latter method, as quickly as possible. The diameter of the flushing pipe should be from 2½ in. to 3½ in., the head or height at which the tank is fixed usually being taken into consideration in addition to the other points mentioned. The feed cock should be adjusted so that the tank will fill and empty the necessary number of times during the day. The exact number cannot be stated owing to the great difference between the usage of various sculleries. One detail must not be lost sight of, and that is, that if the flushing is not done frequently and much hot water is being used, the contents of the trap become so heated that a great deal of liquid grease will pass into the drains. Frequent flushes will so cool the water that the above evil is avoided. On looking at Fig. 612, it will be noticed that the waste pipe is connected to the side of the trap, so that the water does not rush directly to the outlet and carry the grease with it as was explained when writing on Fig. 611.

Vegetable Sinks.

Only in well organised establishments are sinks provided for washing vegetables and salads. Their advantages are manifest, and we need only to deal with their fitting up. It has already been suggested that they should be made of fireclay, white or cream enamelled inside, and they should be fixed on cantilevers clear of the floor, as described for the wash-up

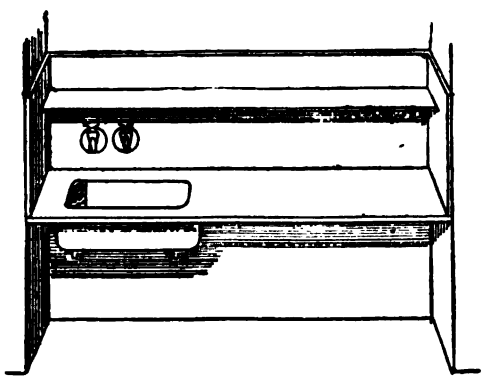

FIG. 613.

sinks. Their sizes and height at which to be fixed above the flow have also been referred to. Slate sinks were much used before the introduction of those above named, but are now less so owing to their dark appearance and also to their cracking when warm water has been used in them.

For ordinary establishments vegetable sinks should have slate tops to them and very high slate skirtings next to walls. Fig. 613 is a view of one fixed in a window recess. The sink is kept near one side of the opening so as to leave as large a portion of the top as possible as a dresser on which the vegetables can be trimmed and prepared for washing, the skirtings being 2 ft. high to protect the walls. In several houses wood is used for the tops instead of slate, and after being used for a time presents a wretched, dilapidated appearance. The wood being frequently wetted is rendered soft and is easily notched by the knife used for trimming the vegetables, until at last the top has the appearance of an old butcher's block, and can neither be scrubbed nor scraped clean.

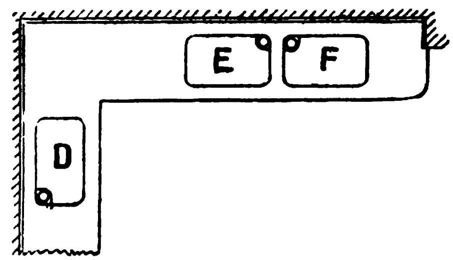

FIG. 614.

In very high-class work marble has been used for the above purpose for the sake of appearance, but although it may look cleaner it does not wear so well as slate.

In a small country mansion in the South of England the vegetable sinks were arranged as shown by Fig. 614. D is the salad and herb sink, and E and F are for vegetables. In the angle of each a strainer and a trumpet-mouthed overflow and waste pipe were fixed as described for the scullery wash-up sinks and illustrated by Fig. 596.

In a very large establishment in the North of England a vegetable scullery was fitted up with every convenience that was thought desirable and that could be of advantage. Fig. 615 is a plan. G is a slate table, H a salad and herb sink; I is for greens, and J J for roots. All the sinks having strainers and combined overflow and waste arrangements, as described for Fig. 614. The walls all round the room were lined with slate slabs 6 ft. high and extending down to the floor, so that a hose pipe can be used and the whole washed as frequently as may be found necessary. At K, are slate bins for holding vegetables, a view of one is shown by Fig. 616, the whole being connected to the wall slates above described. The lower bins are for vegetables and have the floors sloping to the front, in which openings L are made for sweeping out dirt or washing out with the hose pipe. The upper bins M, are made for herbs and small articles, and have openings similar to those below. The small shelf N, is for laying asparagus and such like garden stuff on until

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wanted. In some cases the fronts of the bins are fitted to slide out for easy access for cleansing, but in very large establishments the whole is best fitted up as shown so as to withstand hard usage and knocking about, which would perhaps loosen the slates.

Referring again to the overflow provisions, it may be added that those suggested above are useful when it is desired to leave the cock open for a stream of water to be left running to more thoroughly cleanse what is being washed in the sink.

In some country establishments the gardener will partly trim the garden produce before bringing it into the house, and for sanitary reasons this is the right thing to do. But unless it is going to be used at once the juices will drain out, thus taking off the freshness, and for this reason the cook, or vegetable maid, prefers to do the trimming herself. In this latter case a large quantity of green and other stuff accumulates, and unless soon removed will give off unpleasant faint odours. At O, Fig. 615, is a receptacle for such waste matters, which can easily be carried away by the workman usually employed about the premises. In some cases an opening has been made through the wall for scullery trimmings and garbage to be passed through into a hog-wash barrow or cart placed outside. Where this has been done complaints have been made that the smell of the matter has been drawn into the house through the opening, and rats have been able to come and go at their pleasure. In one case the writer had a 6 in. drain pipe built in the

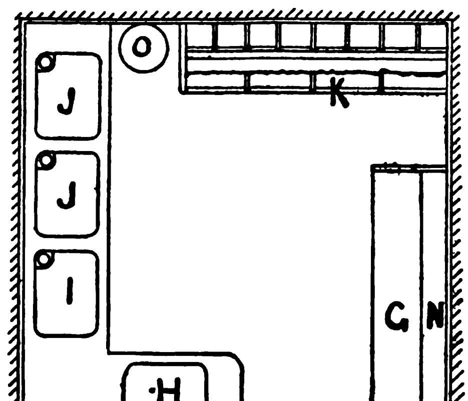

FIG. 615.

wall, and a galvanised cast-iron flap valve fixed on the outer end similar to what is sometimes done at the discharging end of a house drain. But this has not been a complete success. In another case, a garbage shoot, with a balanced valve on the outlet, as shown at P, Fig. 617, was fixed and found to answer much better. Although the valve did not always close so tightly as to keep the smell from the tub passing it was found to be effectual against rats. If they attempted to get through and clung to the valve it would open and they would drop into the tub below. Prior to this introduction the writer has been with another person whose terrier dog caught two and three rats during the evening when he was staying in a country mansion, but after the valve was fixed they ceased to be a nuisance inside the house. The tub on wheels is best when made of galvanised wrought iron. This material is not absorbent like wood, and consequently does not smell so offensive.

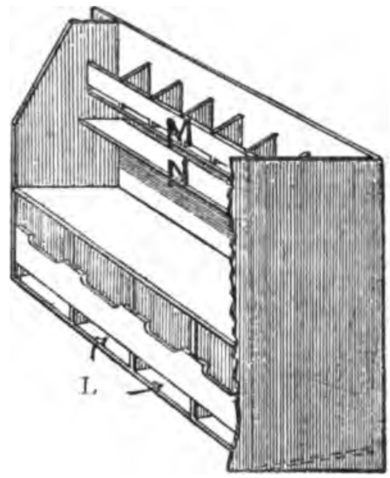

FIG. 616.

The practice of having wooden dressers and keeping vegetables in the drawers is not at all good, although often met with. Frequently the writer has opened such drawers and found potatoes, onions, and other vegetables, either sprouting out or in a rotten condition. An illustration of the evil smells given off by vegetables comes to memory, where the writer was sent to test the drains and sanitary fittings in a west end of London house, as the occupants were sure they were being poisoned by sewer air. The tests having been applied and no defects discovered, attention was given to other matters, and eventually a large hamper was found about half filled with garden produce, which had been sent up from the owner's country estate. The upper portion of green stuff had turned yellow, the lower portion was almost black and giving off an abominable stink, which became worse on turning it out of the basket. Of course, it is very nice when living in a town to have the produce of one's own country garden sent up, but if a week's supply is packed in a hamper and sent up at one time, it surely cannot be suitable for food after the first few days, when decay and fermentation has set up.

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In ordinary mansions, where the amount of vegetables used is not very large, they are prepared in the scullery. Fig. 618 is a plan of the scullery of a country mansion, showing the sink arrangements. Q Q are tinned, copper-lined wash-up sinks, for plates and dishes, having corrugated tinned-copper draining boards at

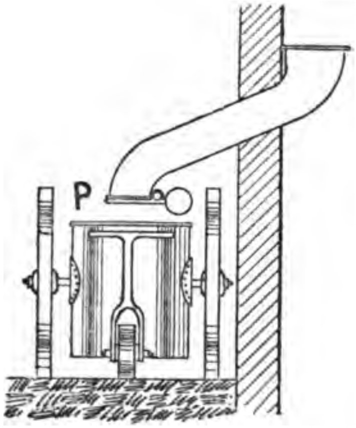

FIG. 617.

R R. At S, is a large size vitrified stoneware sink, in which pots and pans are cleaned and scoured, and at the side, T, is a slate top on which to place such utensils whilst waiting to be washed. U U, are two white enamelled fireclay sinks for vegetables, and having a slate top to them. The wash-up and scouring sinks have separate waste pipes, with traps under the sinks, emptying into a grease trap, V. The

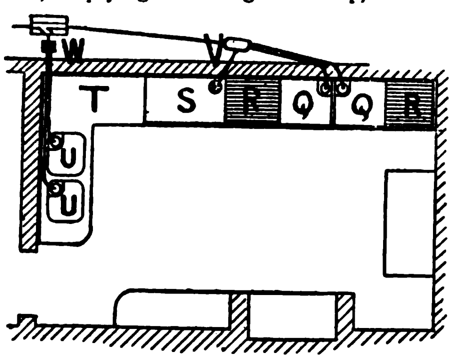

FIG. 618.

pipes from such sinks sometimes get choked, hence the necessity of keeping them separate. If only one pipe were used, and it was choked, all the sinks would be thrown out of use for a time or until the stoppage was removed.

The sinks, U U, have trapped waste pipes emptying into the interceptor at W.

Before leaving the kitchen department we may again refer to another fitting which should always be provided, and that is a wash basin If it is desired that servants shall be clean in their habits, and this refers especially to those who have the preparation of food, proper conveniences must be supplied for their use. With this reminder we can now pass on to sinks in other parts of houses and deal with those in butler's pantries.

Butler's and other Sinks.

In small establishments, where three or four servants are kept, and the parlourmaid has to do the duties of a butler, a room is generally reserved for silver plate, glass, and china. Such utensils require careful usage, and it would not be safe to send them to the scullery for cleansing. In such houses one sink has to be used for all the above purposes. Opinions differ as to what material is the best for their construction, but if a few minutes are devoted to thought on the question a more satisfactory conclusion can be arrived at. In large numbers of houses, built years ago, we find slate sinks; but these, although impervious, have a dark look, and crack when hot water is put into them. They scratch silver plate, and are very destructive to glass and china. These remarks apply to all sinks which are of a hard nature, although the white enamelled fire-clay have a cleaner appearance than the others named. Those made of wood are the best when judged from the destructive point of view, but are objectionable for the reasons given when describing such fittings for sculleries. For ordinary wash-up purposes a tinned-copper lined sink is the best as it wears well and does not injure plate and glass. But, here again, there are objectionable details. When greasy silver plate is being washed, soap has to be used, and this matter sticking to the sides renders the fitting unsuitable for washing glass. In some houses it has been found to be an advantage to have a fireclay sink, as shown by Fig. 598, but with draining boards at the sides, and use tubs for washing in. When this is the case the tubs should, after using, be placed in the sun to dry, and not be shut up in the sink, or placed, when wet, in the enclosure beneath. The tubs themselves should be turned out of solid blocks of wood in preference to being made by a cooper. And separate utensils should be used for frail goods, such as glass or china and silver plate. In some houses where one sink has to do duty for all purposes, the writer has seen extra large draining boards at the sides, on which the articles, after washing, have been placed, and then rinsed by means of a hand watering pot or a small hose pipe and rose, as used for shampooing purposes.

In larger establishments, two and three wash-up sinks are sometimes fixed, each fitting being retained for its especial purpose. Where men-servants are kept the sinks are used by them as lavatories, and where no proper bedroom convenience has been provided they have

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sometimes to answer as urinals also. These disgusting practices have been referred to before, and remedies suggested, but are again mentioned with a view to impressing upon readers the importance of being thorough in arranging such fittings in a sanitary manner. At the same time they must remember that in the majority of cases the dinner water bottles are filled at the taps over the pantry sinks, such taps having their nozzles in a filthy condition, from splashings, and covered with green verdigris. In very few cases, indeed, do the servants keep the taps clean and bright.

There are several other objectionable details in connection with our subject which may be referred to with a view to suggesting remedies. One is the practice of putting a large lump of ice into a dirty sink, breaking it up into small pieces and then serving it up at the dinner table without any attempt whatever at washing it or cleaning off any filth that may be adhering. At the same time small holes are made in the bottom of the sink by the picker used for breaking the ice. The sinks are usually made much too small for their purpose, so that articles being washed can be jammed in. In addition to this the cocks for supplying water are usually fixed near the centre, at the back, thus occupying a certain amount of space, and which would not be the case if they were fixed at one end. Neither should these be too low down, so that a jug or can cannot be got under the nozzles without risking a breakage, or causing the water pipes to leak by straining the cocks upwards. Enclosures are always objectionable for reasons that have been given, but it is of little use preaching this doctrine as servants will have them, and if you decline to fix them, will call in another tradesman as soon as you have completed your work, and have their

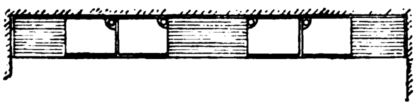

FIG. 619.

"glory-holes" reinstated. Covers to sinks are also objectionable, although the plea is often raised that they form tables on which to clean silver articles. On opening such covers a fœtid odour almost invariably escapes. Where they are insisted upon, ventilating openings should be made, so that the contained air can breathe, so to speak, in and out, and thus become changed.

In very large establishments, the owners of which have a considerable amount of silver, a plate scullery is usually provided, and in this room all the work to such articles is done. Fig. 619 is a plan of such a room that the writer had to do with. There are four sinks, fixed in pairs, with draining boards on which to lay the articles after washing and rinsing. The sinks are lined with tinned-copper, similar to those described for scullery use, excepting that they are not so deep. To suit the large dishes in one establishment it was found necessary to have them about 3 ft. long by 2 ft. 3 in. wide. As the plate scullery is not used daily, so as to entail hard wear, the draining boards are usually made of wood, but it is an advantage to have them covered with corrugated tinned-copper, and place woollen cloths on them to prevent the dishes, &c., from slipping or being scratched. Here, too, it is necessary to keep the cocks well out of the way.

In houses where the glass is kept in cases in a special room, it is usual to have two sinks, these being lined with tinned-copper. They

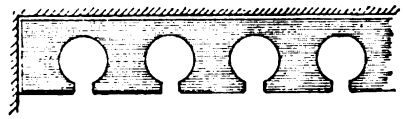

FIG. 620.

should not be too large, or so that too many articles can be placed in them at one time. The draining boards should be ample in size, fixed quite level on the surface, the flutings only being made to fall to one end, usually to the sink. In addition to the latter, bottle racks should be fixed on which decanters can be placed to drain after being washed. Fig. 620 is a plan of part of one shelf in such a rack. The shelves should not be too close together so that there would be risk of knocking the decanters together when placing them in position, and neither should they be too high or difficult to reach. It is best to place such fittings on one side and not over the sink.

The above remarks apply to sinks in china closets, the only difference being that they should be one or two inches lower. In this case, women of ordinary stature, and in glass-rooms, men, sometimes very tall, have to use them.

In connection with the culinary department, a pastry-room is sometimes provided, and a sink is necessary in it. One made of fireclay, white enamelled inside, is very good. That shown by Fig. 598 is suitable, and fitted with white veined marble at the sides, to form tables, with very high skirtings of the same material, and the walls covered with white glazed tiles, the room looks clean and cool. As described for others, the sinks should be fixed on cantilevers, and should not have any enclosures or cupboards. All utensils and articles used should be kept on marble shelves round the room. The previous remarks made on the position of the cocks and also the trapping and waste-pipe arrangements of the vegetable sinks apply also to this and the sinks above described.

In all good houses a still room is a necessity. Not of the kind as used years ago when all essences, for either culinary or toilet purposes, were distilled or made, but where the light foods for breakfast and tea are prepared. Fig.

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621 is a plan of one in a nobleman's mansion. A is a cooking range, B an oven, C a hot plate, and D a pair of tinned-copper lined wash-up sinks, as illustrated by Fig. 596, excepting that draining boards are fixed instead of the high

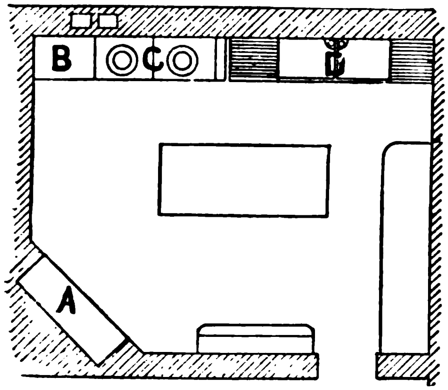

FIG. 621.

end. In a general way the still room may be described as a small kitchen, and is fitted up in the same manner. When the family is away and only servants left in a house, the still room is frequently used as a kitchen. This is also the case when only a small portion of a family is at home. In connection with the servants' offices in country mansions sinks are required in the boot-room, brushing-room, lamp-room, gun-room, and servants' hall. That in the boot-room is best made of enamelled fireclay, as shown by Fig. 598, but with a high back and having draining boards, or slabs, at the sides. The brushing-room should have a tinned-copper lined sink, about 10 in. deep, with sloping boards at the sides, on which hunting clothes and aprons can be scrubbed and cleaned. A small fireclay sink is all that is necessary in a gun-room. The latter should always be in an out-building if possible, some distance from the house, on account of some little danger attending the storage of ammunition. The lamp-room is usually inside the house, but here, too, an outside position is best, especially when petroleum or other oils are stored in it. Not only is there some little risk of an accident occurring and the oil catching fire, especially when it is splashed about and the surroundings saturated, but the odours have been traced to different parts of a house and complaints made about them. The sink should be enamelled fireclay, and the dressers on which the lamps are trimmed covered with sheet zinc turned up against the walls and folded over a bead on the front edge to prevent spilled oil running onto the floor. The latter should be of impervious material. The breakfast or tea crockery, &c., used by the servants at their meals is usually washed in their hall. For this a medium size tinned copper lined sink is usually fixed, in some cases with draining boards at the sides, and with covers extending over the whole, as shown by Fig. 622. The objection to these latter have been given, but the plea has been raised that sometimes entertainments are given, and servants' visitors received, in this room, and the sink looks un-

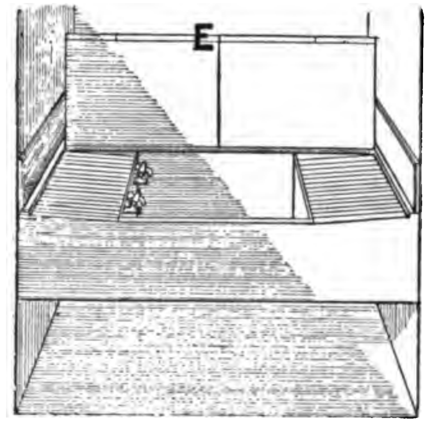

FIG. 622.

sightly. In the figure the lids are shown open, and at E is a curb which, when the lids are shut, fills up the opening above the sink in front.

In some houses it is an advantage to fix a sink for the nursemaid's use. When of white-ware it looks nice and clean, and when dirty shows lack of attention on the maid's part. On no account whatever should this sink be used for the reception of slops. The remarks that have been made on other details, such as enclosing, trapping, and treatment of waste pipes apply to all these latter sinks excepting those in the still room. In this case the waste water should empty into a "flush-out" grease trap as described for the scullery, and shown by Fig. 612.

Housemaids' Sinks.

In all well organised establishments a room or rooms should be set apart for the housemaids to keep their brooms, pails, cans, portable baths and such like utensils, and for them to do certain kinds of work in. As with W.C.'s, it is often thought that any out-of-the-way place, or a cupboard beneath the stairs, is all sufficient for the purpose. But no greater mistake can be made. These places are generally near bedrooms, and any bad odours in the neighbourhood will penetrate into the rooms for the occupants to breathe. When ill-lighted and unventilated these closets invariably smell offensive, especially when crowded with various utensils, dirty slop pails, sponge baths, wet rags and cloths, and other matters. It is true in numbers of houses portable baths are pushed beneath the beds out of sight, but this practice is almost as bad as keeping the pot-de-chambre in the same position. There is little doubt that

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this is the cause of a great many damp beds and the unpleasant odours given off from the latter, especially when made of feathers. The baths should be kept in a well ventilated closet, or, if they are left in the room, they should be thoroughly dried after usage and left exposed. All slop pails should be scalded out after using, and placed while still hot to dry, not bottom upwards, but open so that no watery vapour is retained in them. The towels, too, should be scalded and hung to dry, and not be left in a wet condition in the pail or thrown into a cupoard. All this points to the necessity of plenty of light and fresh air. Certain conveniences must also be provided for the servants' use, otherwise they cannot be clean and do their work properly, although desirous of doing so. It may be added that it is of little use teaching domestic economy in our elementary schools to girls who are eventually going out to service, unless householders give them every convenience for practising what has been taught.

An important detail in the housemaid's closet is a plentiful supply of boiling or very hot water. This latter is very essential as, when it has to be carried in cans from the basement, or other remote place, it is either not used at all or an insufficient quantity is fetched, resulting in the chamber utensils being lined with a brown fur inside, and the slop pails and cloths having a strong smell of urine.

One of the first necessities is a sink in which bedroom crockery, &c., can be washed. The best kind is one lined with tinned-copper and having a plug over the waste for keeping the water in the sink. High backs should be provided for protecting the walls and a metal covered draining board at one side. The size of the sink need not exceed 2 ft. long by 1 ft. 9 in. wide and 1 ft. deep. An overflow arrangement is very necessary to carry away the water if the taps should be left running when the waste plug is in its place. The taps should be high enough for getting pails beneath, and here, too, enclosures should be avoided. We have dealt with this fitting as being used for one purpose only, and it now becomes necessary to take up another side of the question, namely, the disposal of bedroom slops. This is a very vexed problem, as so many architects and sanitary engineers look at it from different points, and each have good arguments for their views on the matter. One view is that bedroom slops should always go into the W.C.'s, but in practice it is found that with the waste water other things are thrown down, and which break the W.C. basins or choke the traps. The temperature of the slops is such as to cause expansion and contraction to such an extent as to eventually break the soil pipes. The seats, too, are continually being wetted. These troubles are constantly cropping up, and to prevent some of them separate sinks have been provided, the waste pipes being connected to the soil pipes, with the same results to them as when the W.C.'s have been used. On the other side of the question it has been reasoned that the filthy water thrown down a sink, the waste pipe from which empties into a gully or intercepting trap, always emits bad odours when laying in the latter. The writer has met with such examples, but in each case he found the intercepting traps to be so large that the contents were never changed, and only stirred up at each discharge. He also found that no clean water was sent down the sink to wash the channels through which the slop water had passed. He has also had cases where houses were left for a season, with only two or three servants in charge, where the water had evaporated out of the traps. The waste pipes being connected directly with the drains instead of being cut off by interceptors, and drain air was passing so freely into the houses as to create alarm as to their sanitary condition. Invalid's and some kinds of nursery slops should be thrown down the W.C.'s, but for the reception of ordinary bedroom and housemaids'

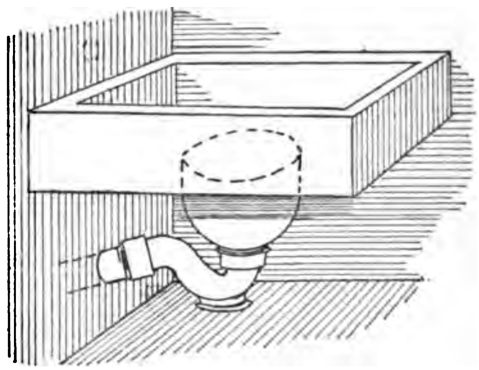

FIG. 623.

waste water proper sinks should be provided, and these should have separate waste pipes properly disconnected from the drains.

WE will now deal with a few of the sinks that are sometimes fitted up for housemaids' use. Fig. 623 is an elevation of one kind frequently met with, and consists of an ordinary W.C. basin, with earthenware trap joined to the waste pipe by means of a putty joint. Over the basin is a lead lined deal sink, with a large round hole in the bottom, into which the lead is worked so as to project into the basin a short distance. There are many weak points in this arrangement. Owing to expansion, and its opposite, the putty or red lead joint soon becomes defective, and the slightest movement of the basin renders the joint between it and the trap into a similar condition. The basin is sometimes broken by heavy articles being pitched into it with the slops, and in the absence of any grating or strainer the trap becomes choked at times with house-flannels or

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some other article of domestic use. If the lead sink is only a few inches deep it is almost impossible for the maid to pitch the slops into the basin beneath, resulting in the fouling of the former. If the latter is filled to overflowing the slops run onto the floor and sometimes damage the ceiling beneath. The woodwork under the lead sink is continually being wetted by splashings, and is often found in a rotten condition and smelling offensive.

What is thought by some people to be an improvement on the above kind of sink is shown by Fig. 624. These are made by nearly

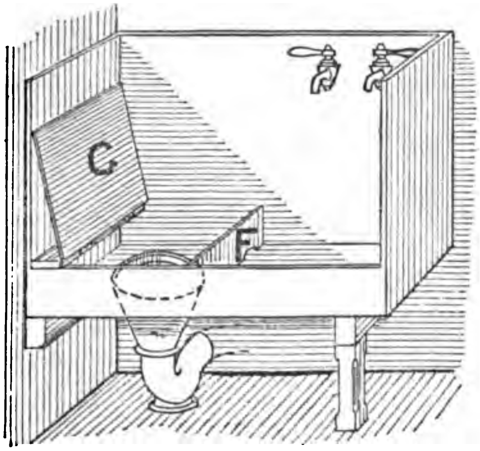

FIG. 624.

all manufacturers of plumbers' materials, and although better in some details than Fig. 623 are far from being perfect. The evils of the basin, trap, and jointing are retained, although in some cases lead traps with soldered joints to the waste pipes have been introduced. The chief blot is the space, or so-called joint, between the basin and the sink. The principal improvement is the upper sink, which is of slate, and when enamelled presents a smart appearance. But this only lasts for a time and soon begins to present an unsightly appearance. In a few cases the slates have been found to crack, especially in the bottoms where hot water from the tap has dripped upon them. The high back and ends are very good for protecting the walls from disfigurement by splashings of slops, but the height of the kerb in front of the basin renders it difficult to pitch the contents of a pail into the latter. In the drawing F is a division for preventing articles slipping into the basin, but with spaces cut out of the bottom edge for water to run away. The division also acts as a support for the draining board G, which is hinged for lifting when the basin part is being used. In some examples a galvanised iron grid is substituted for the draining board. The draw-off cocks are in a good position, and are not liable to be splashed with slops or filthy water. Several of this kind of fittings are enclosed. Others are fixed on especially made cast iron legs or supports, and a few are found to be fixed on cantilevers cut and pinned to the back wall. The latter is best, as the space beneath is left clear for cleansing, but can only be adopted when the back wall is made of brickwork. When a stud partition is behind the sink it then becomes necessary to use especially made brackets which can be fixed with screws.

Another kind of slop sink is shown by Fig. 625. The details above enumerated apply generally speaking to this one, excepting that the cocks are closer to the slop shoot.

Fig. 626 is a sketch, with the enclosure removed, of a housemaid's sink arrangement fixed from an architect's drawings in a nobleman's mansion. At H is an enamelled cast-iron slop shoot which holds rather more than a bucket, and thus lessens the liability of an overflow should a house-flannel or other obstruction get into the trap before being noticed by the user until too late to stop. I is a draining board on which cans or pails are stood when being filled with water from the cocks. The board and also the flashings at back and ends are all covered with sheet lead. The sink is flushed through the pipe J, which is connected to a two-gallon syphon action flushing cistern similar to those used for W.C.'s of the ordinary washdown kind. But the flush is not thorough in that it forms a vortex, the water whirling round the basin instead of streaming down the sides and washing all filth down to the outlet. Copper sparge pipes have been tried for flush-

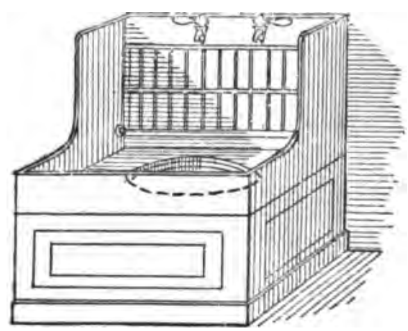

FIG. 625.

ing, but, although superior to the side inlet arm, dirt has been found to accumulate on and behind them and look unsightly.

During the last few years many improvements have been made in the manipulation of materials, and it has now been proved that some of them can be moulded into forms which a few years ago was thought to be impossible. Even such coarse substances as fireclays can be made into certain forms as easily as porcelain clays. The result has been some improved kinds of slop sinks.

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Fig. 627 is a sketch section of such an one, showing the hollow or flushing rim, the flushing being done by a cistern as last described. Being of a good size it is not liable to be filled to overflowing. Those made for hospitals and similar institutions have the bottoms flatter so that bed-pans and other invalids' conveniences can be placed in them for scalding and cleansing. When fitted up on a galvanised iron frame with legs there is room for access for cleaning the space beneath, although in this case, too, the legs should be avoided if possible. The trap is attached to the sink by means of a brass connection at K, which can be open at the top or have a grating or crossbars, as may be desired. The bars are preferable as they can be cleansed when dirty, do not form an obstruction to the free passage of slops, and at the same time will prevent anything getting through that would choke up the trap. A lead trap is used in

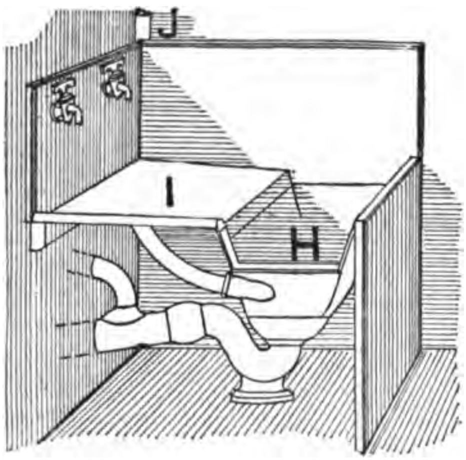

FIG. 626.

connection with this sink, a wiped soldered joint being made to the union, and a brass cleaning cap soldered in, as shown in the figure, for removing any obstruction or passing a flue brush through for cleansing the inside. The sinks are made very strong so as to resist fracture, and being white enamelled inside present a clean appearance, or if neglected show the dirt.

An improved combination draw-off sink and slop sink, made of fireclay, white enamelled inside and buff out, and having a flushing rim, is shown by Fig. 628. The slop sink L, although square on plan, has hollowed inside angles so that no filth can accumulate beyond the reach of a scrubbing brush, and the top edge is rounded, thus not presenting any sharp arrisses to become chipped by being knocked against with pails or cans, &c. The flushing pipe M should not be less than 1½ in. diameter. The flushing cistern N is on the syphon principle, which has the advantage of ensuring the whole of the contents being used at each flush, the cistern holding from two to three gallons of water. The sink is supported on a cast-iron bracket fixed to the wall, and the lead trap O is fastened to the sink by means of a flange and bolts. The wash-up sink P is made of the same kind of material as the other, and has also hollowed inside angles and rounded top edges. This sink is made with high back and end, as shown in the figure, or

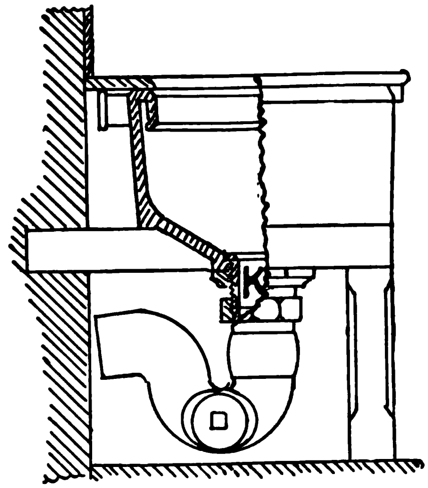

FIG. 627.

with the sides the same depth throughout for fixing in rooms with tiled or glazed brick walls. Provision for a possible overflow is made by the lip Q, which hangs over the slop sink. The waste pipe is connected to an especially provided arm in the slop sink and, the ends being open, a small wire brush can be passed through for cleaning off any filth that may be adhering. The whole of the combination being so arranged that all parts can be cleansed when necessary. When high back sinks are used any spaces from irregularities round the top edges next to walls can be filled up with cement to prevent water or dirt getting behind, and obviate the use of wood cappings which, being absorbent, would be liable to saturation. When floors and walls are made waterproof the whole can be washed down and thus kept thoroughly clean. Although sometimes difficult in application, this should be the leading principle in arranging all kinds of sanitary fittings, and more especially does this apply to hospitals, infirmaries, and similar institutions.

Mention has been made of the necessity for light and ventilation in housemaids' closets. The former is of great importance, otherwise a servant using a slop sink fixed in a dark position is liable to throw the contents of her pail outside the sink, not only saturating the floor but damaging any ceilings below. As

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accidents, the upsetting of a pail for instance, are always liable to occur the floors should be made watertight, and where they are made of wood should be covered with sheet lead with the sides turned up an inch or two against the walls and dressed and nailed to a small deal

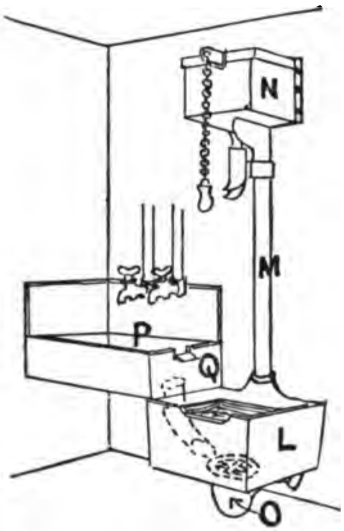

FIG. 628.

fillet in the doorway. An overflow pipe from the lead safe is an advantage, although it may not be considered as being an actual necessity.

The position of a housemaid's closet should be as carefully considered as that of a W.C. Although the two are frequently, for convenience, fixed adjoining each other, the entrances should be kept separate and, if possible, not in sight of each other, especially in hotels and mansions where the sexes are mixed. Decency should be considered, and it is very unpleasant for a gentleman to be detained in a

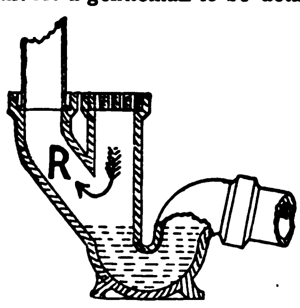

FIG. 629.

W.C. during the time a maid is doing her work close by.

Having now dealt with most of the details in connection with slop sinks we can now pass on to the treatment of their waste pipes. The material for them should be as was described for baths. When fixed inside the house or building, galvanised wrought iron with screwed joints is best for the main stack, the branches being made as shown by Fig. 535, and to prevent breakage by expansion and contraction they should be bent as shown by Fig. 536. When cast-iron stacks are fixed the joints

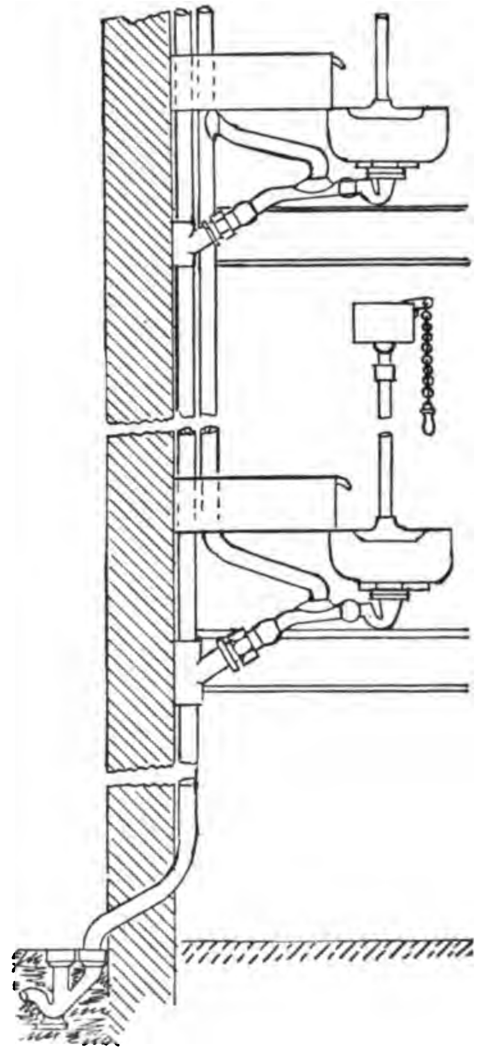

FIG. 630.

should be as shown by Fig. 537. When the waste pipes are fixed outside the house lead is the best material to use, the joints being made telescopic, as shown by Fig. 534, to allow for the movement caused by hot water discharges. Opinions differ as to outside or inside being the best for waste pipes, but previous lectures having gone over the *pros* and *cons* we need not again cover the same ground.

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A vexed question amongst experts is that of disconnecting the waste pipes from the drains. Experience leads one to the conclusion that the weight of evidence is in favour of disconnection. But to prevent smells emanating from the trap it should be of a small size, and the slop sinks should each have a flushing cistern which should be used each time slops are thrown down. The trap should not only be of a small size but so shaped that it is kept clean by usage, the contents frequently changed, and so deep that, when coming from a considerable height, the water will not boil up through the grating. Fig. 629 will convey to the reader an idea of what form such a trap should take. If the size of the main stack of waste pipe is 3 in. the internal diameter of the body of the trap should not be any larger. The column of water coming down the waste pipe will exert a better cleansing force if it is not broken up or turned from the straight line of direction, hence the shape of the inlet arm at R which directs the water into the bottom of the trap where it can scour through into the drain, helping to keep that clean. The bottom end of the waste pipe being above the water in the trap, air can pass through as shown by the arrow.

Fig. 630 is an elevation of a part of a tier of four combined wash-up and slop sinks showing the waste and ventilation pipes. The traps have branch vents as shown in the figure, and are arranged similarly to those for W.C.'s. The mistake is often made of fixing these latter pipes much too small. When a pailful of slops, sometimes as much as four or five gallons, is thrown down a sink and passes away in four or five seconds, the air inside the waste pipe is driven out with great violence. Other air entering through the ventilation pipe has to travel at the same speed as that displaced. When the pipe is small the speed must be increased to get the same quantity through in the same amount of time. In doing this the friction is very much increased, resulting in an insufficient quantity entering, the remainder passing through the traps, pushing out the water and leaving them partly or wholly unsealed, to fill the partial vacuum inside. In everyday language we say that "the traps syphon." With very high stacks of waste pipe the water from the upper fittings forces the air before it, and some of this is driven through the lower traps, and we say that "the traps blow." To prevent either of these actions it is necessary to have the vent pipes of a good size, never less than the waste pipes, and in some cases much larger. We may say that the action is very similar to that which takes place in soil pipes when valve W.C. apparati are fixed, hence the necessity of having an ample supply of air through the ventilation pipes.

In conclusion, it may be added that the height of the slop shoots should not exceed 1 ft. 6 in., and the wash-up sinks 2 ft. 6 in., above the floor. No taps for filling toilet bottles should be fixed over a sink into which dirty water or bedroom slops are thrown.

In hotels and clubs sinks should be fitted up in much the same way as for private mansions, the only details that we may allude to are that all such fittings should be of a fairly good size and very strong, as they are subjected to very hard usage. The sanitary arrangement of the pipes and system of trapping and ventilating being on the lines above laid down.

MILK DAIRIES.

IN milk dairies and food larders particular attention should be paid to the sanitary arrangements, and ample provision made for the servants to keep the place and all the utensils quite clean. To impress the importance of this on readers, I may mention that an eminent doctor has been heard to say that contaminated milk is as much answerable for typhoid fever cases as are bad, or defective drains. Not that the cows give milk that is charged with typhoid germs, but its after exposure to insanitary conditions or retention in dirty utensils, or those washed in foul water, which leads to the propagation and spread of the disease. This is not the place to explain all the troubles that arise from contaminated milk, but a few words upon how this most important article of diet is polluted may strengthen the rules hereafter laid down for prevention. An unhealthy cow cannot possibly give pure milk, but even a healthy animal has its udder fouled by contact with its own excrement, in which it frequently lies. In very rare cases indeed is the filth sponged or washed off the teats. The milker usually squeezes a little out of one teat into his or her hand, first one, and then the other, to make them soft, and then lubricates the "dugs," softening them, so that the operation of milking is rendered easier. Where several cows are being done the hands are dipped into the pail of milk for each succeeding one for the same purpose. Independently of any other reasons, the above is quite sufficient to prove the necessity of boiling all milk before drinking

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it, and which rule is endorsed by all members of the medical profession who have given any thought to the matter. The pails, too, should be frequently scalded, not simply washed with hot water but rather placed in a large vessel of boiling water or subjected to a steaming process. In many cases the milk pail is used also for watering the cattle, or in cottages for ordinary domestic purposes, and such usage should be strongly condemned. With regard to the places in which milk is kept, they should always be in a shaded position, cool, and well away from the influence of the sun's rays, and at the same time so arranged that frost can be excluded in the winter time. The floors should be of impervious material with hollowed fillets in the angles formed with the walls, as shown in Section, Figs. 515 and 633. In many milk larders the floors are paved with bricks or local stones in slabs. Such floors are almost invariably found to be in a dilapidated condition and pools of liquid, either milk or water, lying about. In many cases the jointing material has disappeared, and the spaces between the bricks or stones, and also the ground beneath, saturated with sour, foul smelling, matter. For presenting a smart appearance tiles, laid in fancy patterns, are sometimes used for floors, but when the surfaces have become worn by traffic or pails, &c., they are to a certain extent porous. Spilt milk will soak into them, resulting in an unpleasant, sour odour pervading the place. There is nothing better than good Portland cement concrete, with trowelled surface, for dairy floors, and for ornament when desired, by varying the colour of the sand in the finishing coat, a border and centre to almost any pattern can be designed and executed.

On no account whatever should a drain from the floor of a milk or any other larder be in direct communication with any sewage drain, and neither should there be any gulley trap inside the building. The floor should be slightly higher in the centre and laid to fall towards an open channel or gulley running all round the larder just beneath the front edge of the shelves. The channel should fall to one point and be continued through the outside wall to a gully trap some three or four feet away from the building. A hinged, galvanised iron grating to be fixed outside the wall-opening for keeping out rats and other vermin. When a trap is fixed beneath the floor it does not get washed out so often as it should. Spilt milk runs, and spare or sour milk is thrown, into the trap, where it will decompose and give off bad odours, or curdle into a solid mass and block up the waterway. The writer has found such traps defective or without water, and drain air escaping. Drains beneath the floor are frequently found in a leaking condition, and as they are rarely, if ever, ventilated, the least compression inside forces the air outwards through the defects. Hence the wisdom of abolishing any underground channels and having them open on the surface where they can be scrubbed and kept clean. By having the trap outside and a few feet away from the building, any gases escaping would be diffused in the external air, and the risk of their getting near the milk very much reduced.

The walls of a dairy should be built with white glazed bricks set in cement. White tiles on ordinary brick walls are a good substitute, but should be bedded in cement. When plaster of Paris is used for that purpose the tiles will frequently fall down, being pushed away by the expansion of the plaster which swells when damp or wetted. Recently a patent tile has been manufactured with what may be called "dovetail" recesses in the back. When bedded in Portland cement it is impossible for them to fall down, and they cannot be removed without destroying them. Fig. 631 is a section of a portion of one tile, showing the keyed recesses at the back.

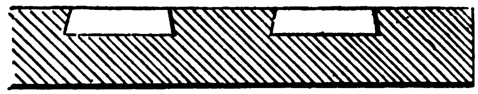

FIG. 631.

The ventilation of a milk larder should always be carefully arranged; the principal points to be considered are as follows:—Wall openings on opposite sides are necessary to get a cross ventilation, but where this cannot be done inlets and outlets should be provided and so arranged that there are no corners or places where the air is stagnant. Incoming air should be drawn from a pure source, and where this cannot be done, owing to the presence of a farm-yard, piggeries, middens, rubbish shoots, and such like surroundings, the site should be given up and a new one found. The writer has seen underground channels for the admission of fresh air, but these should be condemned, as it is vitiated when passing through. All windows and air inlet openings should be of a good size and covered with very fine mesh perforated zinc, not only for keeping out flies and spiders, but dust matters floating in the air. Coarse canvas shutters are sometimes used, but these get so clogged with dust, which really shows their utility, that they arrest all ventilation unless they are constantly being taken down and cleaned or washed. To be thorough in our reasoning, it should be added that the air should be filtered before entering any milk larder or other place where food is kept. But such arrangements, when neglected, become so foul that the air passing through is rendered worse than it would be without them.

The shelves for the milk pans should be made of an impervious material. Wood and sandstones are very unsuitable owing to their porosity. They also wear uneven by the move-

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ment of the utensils. White or veined marble looks nice when new, but is too soft to withstand hard wear. Very hard black marble and slate are good. All shelves should be fixed on cantilevers, cut and pinned into the walls, as shown in section, Fig. 632. The cantilevers being of the same material as the shelves. For keeping the milk cool in hot weather the shelves are sometimes made like shallow sinks, fixed to

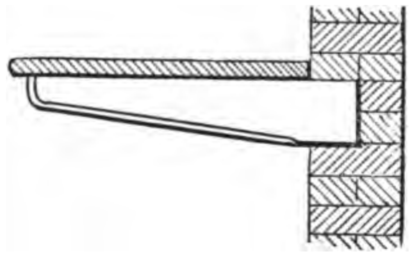

FIG. 632.

a slight fall to an outlet and have a small stream of water running in at the highest end. From the outlet a waste-pipe is fixed for the water to run away, and a small trumpet-mouthed standpipe for retaining the water to a depth of ¼ in. to ½ in. when so desired, as shown in section, Fig. 633. The waste-pipe should be made to discharge in the same manner as an overflow pipe from a cistern, excepting that it should empty at ground level. If the end was some distance above the ground the water would splash about very much. An open channel, with a grating at surface level for keeping out leaves, connected to an interceptor trap a few feet away, as shown in the figure, is all that is

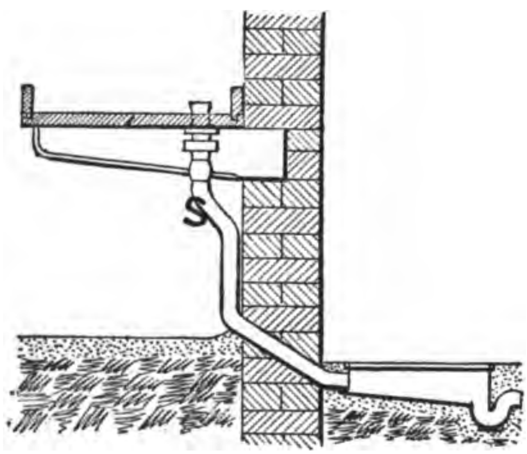

FIG. 633.

necessary, excepting when other waste-pipes empty into the same channel. In this latter case a trap should be fixed at S.

A bib-cock with union on the nozzle and water supply should be fixed in the dairy so that a hose pipe could be attached for washing down the walls and pavement when necessary. The water should come from a pure source, and if a cistern is fixed it should not be in the same place where the milk is kept. For washing the utensils a sink is necessary, but this fitting should be in another room and not near the milk.

A scullery should be constructed near the dairy in which all utensils can be cleansed. The necessary conveniences are a water supply, two sinks, and a copper for boiling water, the latter being of a good size so that some of the smaller articles can be immersed in it. A draining board and rack are also required. The floor and walls should be of the same kind as was described for the dairy, the former being highest at the sides, with hollowed angles next to walls, and laid to fall to the centre. The

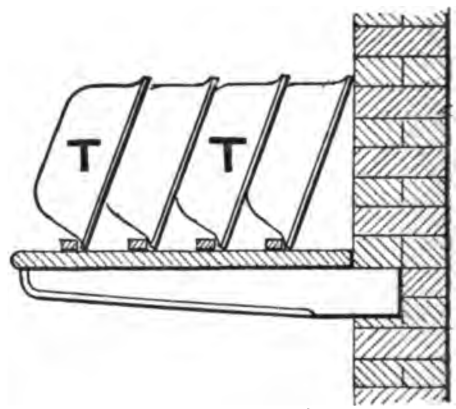

FIG. 634.

slope should not be too much, otherwise servants with iron shod boots or clogs would be liable to slip. A small size gully trap to be fixed at the lowest point, and a 4 in. drain from it to a second trap outside the building. For washing up purposes a very large tinned copper-lined deal sink should be provided, the details being similar to those for kitchen sculleries. A large size stoneware sink is useful for scouring certain utensils in, the trapping and waste pipe arrangements being on the same lines that was described further back. The copper should not be too high, otherwise the dairy maid or man could not reach over for placing the articles to be scalded in it or recovering them afterwards. A cock is necessary for drawing hot water into pails, and thus save the risk of being scalded when dipping. In more ambitious establishments a boiler with cylinder and pipes could be arranged, and hot water drawn at the sinks instead of from the copper, or a steam boiler could be fixed for heating water and scalding the churns, pails, tubs, &c.

A draining board with back and fillets is

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necessary for standing milk pans on edge to drain and dry after cleansing. In many places such utensils are rinsed with cold water after being scalded, but where the water is far from being above suspicion the rinsing should be done with scalding hot water or not at all. For it is useless to sterilise anything adhering to the sides of the various vessels and immediately afterwards cover them with something which would contaminate any milk with which they came into contact.

The fillets on the draining board are shown in section by Fig. 634, and the pans T are so placed that all steam can escape and water drain away.

All cloths, the churns, and wooden articles used about the dairy and for butter making should, if possible, be placed in the sun after scalding to aid their thoroughly drying, and thus do away with the nasty sour smell that is usually noticeable as emanating from them. In conclusion, it may be stated that absolute cleanliness and a liberal use of boiling hot and cold water respectively is far preferable to resorting to disinfectants for keeping anything used in or about a milk dairy clean and fit for its purpose.

HOUSEHOLD LAUNDRIES.

IT is not my intention to deal with the large subject of laundries in general, but only those in connection with private houses and mansions. And neither is it useful for our purpose to discuss the probability of certain diseases, scarlet fever as an example, being communicated from one family to another by the comingling of linen sent to be washed. Suffice it to say that in well organised establishments the risk is very small indeed, and that it is an open question if the sending of linen from a patient suffering from a contagious disease to a public laundry should not be made a penal offence.

In private laundries there are many points that are of interest to plumbers and sanitary engineers. Dealing with the waste water first. Where the water is at all hard, and no proper provision is made for removing the bicarbonate of lime, which is the cause of the hardness, the soap used in washing will curdle to a large extent and foul the drains nearly as much as the grease from a scullery sink. The writer knew of a case where the subirrigation pipes of a small sewage farm were entirely choked with the soap, contained in the waste water from a small private laundry, in less than two years from the time they were laid in. A great deal can be caught by using a trap similar to the one shown by Fig. 261 in a previous lecture, but this requires frequent attention, and should only be used under special conditions.

The floor of the washhouse should be made of impervious material, with hollowed angles next to walls, as was described for the milk dairy. Where washing and wringing machines are used provision has to be made for the waste water to run away. This is best done by forming channels in the floor and covering them at surface level with galvanised cast-iron gratings, as shown in section by Fig. 635. As the machines used are not always stationary a length of the grating can be temporarily removed if necessary, or the water can be allowed to dribble over it, although the former has the advantage in that splashing is avoided. The floor to be laid to fall to the grating, and the channel to empty into an intercepting trap fixed outside the wall of the building. Sometimes the trap is fixed inside to avoid a current of air passing inwards through the opening in the wall. The gratings can be removed for scrubbing and washing the channel should it become foul or dirty, and the latter should be formed with white enamelled stoneware half pipes embedded in concrete.

The walls are best made of white or tinted glazed bricks which can be washed and always

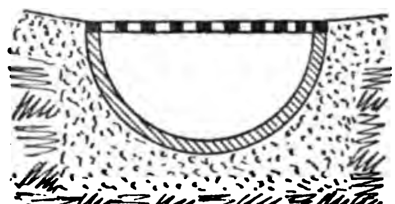

FIG. 635.

present a clean appearance. At times there is a considerable quantity of condensed steam running down such walls, but this is better than having them plastered or limewhited. In either of the latter cases a dilapidated appearance is presented by the crumbling of the plaster or the peeling off of the whitewash or distemper.

Ample ventilation should be provided for taking off watery vapour or steam. Where a steamer or boiling copper is used a hood, with a ventilating flue, should be fixed over it. In several washhouses, without these latter pro-

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visions, the steam is at times so dense that the maids cannot well see what they are doing, and their dresses become so saturated that there is no wonder they are often laid up suffering from colds or rheumatism.

The material mostly used for washing-trays is white pine or deal. They are usually made

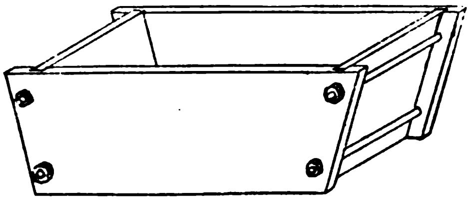

FIG. 636.

smaller in the bottom than at the top, and the advantage is that with a small quantity of water a good depth for immersing the clothes is obtained and there is a fair amount of elbow room at the top. The trays being tapering in shape, there would be some little difficulty in "dovetailing" the angles. Neither is this method good, owing to the swelling and shrinking of the wood being different across and with the grain, so that the angles would soon leak.

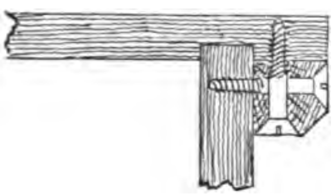

FIG. 637.

Fig. 636, is a view of an ordinary washing-tray, showing the methods of jointing at the angles. Sometimes iron rods, or bolts and nuts are used to clamp the sides together, as shown in the figure, but as the heads project and catch the user's dress they have been objected to and ordinary carpenter's screws, made of brass, substituted. In some cases deal fillets are fitted in

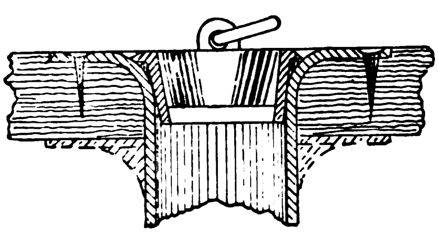

FIG. 638.

the outside angles and screwed to the tray, as shown in the fragmentary section, Fig. 637; the fillets and angles being painted, or white lead and linseed oil used for making the joints water-tight. The disadvantages of wooden washing-trays are many, and we may mention a few of them. The internal surfaces become disintegrated, and splinters of wood injure the

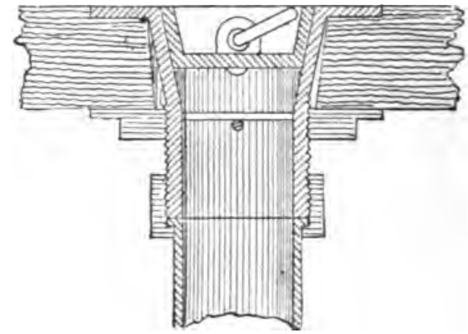

FIG. 639.

person's hands or articles being washed. When left unused for a few days the wood will sometimes shrink to such an extent that the angles will leak. This is avoided by leaving the trays filled with water. The wooden utensils of a laundry almost invariably give off a sickly, faint odour, and the older they are the more offensive smelling they become. The waste connection is generally fixed in a botched manner, as shown in section by Fig. 638. The piece of lead waste pipe is tafted over onto the bottom of the tray, embedded in red or white lead cement and then nailed round the edges. The expansion and contraction of the metal will frequently work out the nails, thus showing their uselessness; the cement becomes hard, brittle, and cracks, and the woodwork round

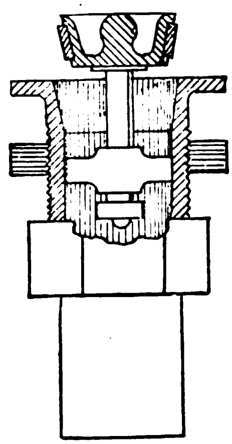

FIG. 640

the pipe, especially on the under side, in a state of decay from being constantly wetted. A much stronger connection is made if a lead flange is first soldered to the pipe, as shown by dotted lines in the figure, as being under the sink. With this no nailing is necessary; the tafting of the pipe into a sinking cut in on the

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upper side will make a watertight joint, if properly done, without the use of any cement, and will allow for a little expansion of the lead pipe and swelling of the wood, when wetted, without interfering with the soundness.

Another mode of connecting the waste pipe is shown in section by Fig. 639. In everyday language this is called a brass, or gun metal, "washer and plug with fly nut and union," and is fixed in the same way as when attached to an earthenware or fireclay sink. The plug is shown sunken with the ring below the level of the sink bottom, so that it is not liable to be dragged out of the washer by the movement of the contents of the tub during washing operations. In some cases a chain is attached to the ring to prevent its being lost, but this has been objected to as it gets entangled in the clothes with the above result. It must be admitted, however, that without some protection such plugs are continually being lost. So-called locked plugs, as shown by Fig. 288 in my book, "Plumbing Practice," and here reproduced, see Fig. 640, are very suitable for some kinds of wash-basins, but are not quite satifactory for washing-trays. There are other methods for emptying such fittings, but there is room in the manufacturing market for some one to invent an improved fitting for the purpose.

In many household laundries the waste pipes from the wash-trays empty into open troughs fixed beneath them, the water then running into a gully trap fixed for the purpose. Such arrangements are far from being satisfactory. In some cases that the writer has come across the troughs appeared to have been made of wood by the estate carpenters, and although the workmanship was good, the arrangement could not be considered sanitary, as foul, black, evil-smelling matter has been found in such troughs. A short time ago the writer was testing the drains of a mansion in Cheshire, and smoke escaped out of each of the waste pipes, which were not trapped or disconnected, of a range of nine wash-trays, and also through the floor of the ironing-room, which was in a separate building. The drains and culverts were in a dreadful state, and received not only the house sewage but also waste water from laundry, milk dairy, and drainage from the stables, cow byres and piggeries. In this particular case there is little doubt that the household and body linen was saturated with drain air in the interval between washing and removal into the mansion. To return to our subject of materials for wash-trays, Fig. 641 shows a range of tubs of English make, fitted up on the so-called American pattern. The illustration is copied by permission from the manufacturer's catalogue. The accompanying description runs as follows: A set of three "Imperial" roll-rim wash tubs, glazed white inside, buff on roll-rim, with bronzed iron standards, marble or hardwood back, nickel plated taps, waste pipe and trap, rubber stoppers, chains and soap cup. The above is a suggestion for fitting up "Imperial" porcelain roll-rim wash tubs in the American manner,

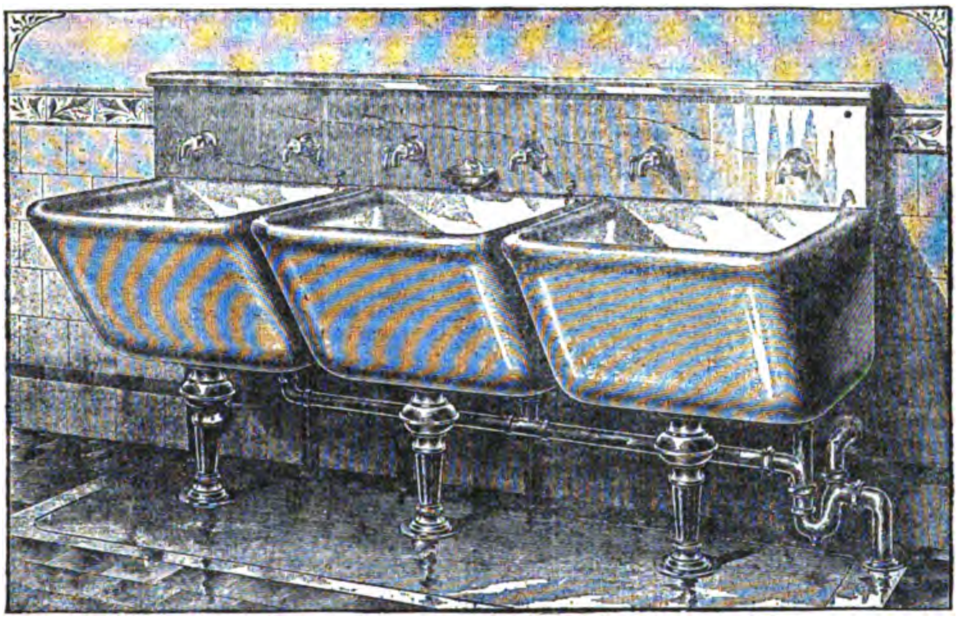

FIG. 641.

all the fittings being nickel-plated and exposed, so that the slightest fault or leakage is at once seen.

As can be seen in the illustration, the tubs slope back on the front and allow room for the person's knees ; any water splashed over runs down onto the floor, which is made of impervious material and dished to a fall. There are no corners in which filth can accumulate, or material which can absorb water or soap suds, to afterwards smell offensive. The taps are well out of the way and will not interfere with the usage of the tubs. The whole fitting appeals to one as being very good and free from sanitary defects, although there are one or two points in the waste pipe arrangement which do not quite agree with some of the writer's remarks in former lectures. Although three tubs are shown, a lesser or greater number can be fitted up as may be required. The tubs are made of fireclay.

The waste pipes from laundry tubs, &c., should be trapped, ventilated and disconnected from the drains as has been described for sinks and other fittings. The water supply, too, should be free from contamination. When clothes and linen are washed and scalded and thus rendered sanitarily clean, it is unwise to afterwards rinse them in water which, although clear and bright, may not be pure or free from contamination. Rain water from dirty roofs, stored in tanks, which are very rarely cleaned out and lime whited, cannot be considered as ideal or entirely suitable for the final stages in washing. And underground tanks with overflows connected to sewage drains are sometimes converted into cesspools, when a sewage blockage occurs. At a large convalescent home in the country, the writer attributed a serious outbreak of erysipelas to an underground rain water tank, which was found to have sewage running into it, and which supplied the laundry. Having now dealt with most of the plumbing and sanitary details of private laundries—with the machinery and special appliances for washing we have nothing to do—we can change our subject. There are a host of others which come under the heading of sanitary plumbing, but it has occurred to me that probably an entire change would be acceptable to readers, leaving further sanitary details for a future time. As problems in hydraulics and hydrostatics are constantly cropping up, and a knowledge of the sciences of those subjects is of great importance to the student plumber, we will devote a few lectures to their consideration.

PHYSICAL PROPERTIES OF WATER.

IT is first of all necessary to have some knowledge of the physical, or natural, in distinction to chemical, properties of water. We see it around us in many forms, such as clouds, dew, fog, hoar frost, rain and hail, as a liquid and as a solid. The liquid condition is that in which we are interested, although the solid state has points which will be dealt with so far as plumbers' work is concerned. As a liquid we can pour it from one vessel to another, or convey it through pipes from one place to another, either by gravitation or forcing. Composed of particles held together by natural forces it cannot take any form of its own, but only of that of any vessel containing it. The particles are free to move in any direction, and do so when influenced by any motive power. Water has weight; an empty pail does not weigh so much as one filled with water. A vessel which measures inside 1 ft. each way in length, breadth and depth, has a capacity of 1 cubic foot, and this mass, if of fresh water, will weigh 62½ lbs., and contain 6¼ gallons. By simple division, we find that a gallon of fresh water weighs 10 lbs., and a pint 1¼ lbs. For these weights to be correct the temperature of the water must be about 40 degs. Fahr. scale. If above or below this temperature the bulk or volume is expanded. As an example, if the above size vessel was filled with water at the temperature given, and then heat was applied until the water boiled, the temperature being then 212 degs. Fahr., expansion would take place, the surplus would flow over the sides of the vessel, and what was left would weigh something about 60 lbs. or 2½ lbs. less than the, what may be termed, cold water. From this we find that the temperature of the water has to be considered when making exact calculations as to its weight. Plumbers may ignore this as it is very rarely indeed that they have to make such close calculations, and it is only mentioned here to show the influence of heat on water. In the above statement the term "fresh water," was used to distinguish it from sea or salt water, a cubic foot of which weighs about 64 lbs., and varies according to the amount of salt dissolved in it. There are various ways for finding the relative weights of liquids, and a very simple one is to have a piece of glass tube and bend it to a U-shape, or make a metal bend and attach glass tubes, as shown in Fig. 642. If one leg is filled with one kind of liquid and the other with another kind, of a different density or

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weight, bulk for bulk, the lightest liquid will stand in the tube at the higher level. If sea and fresh water are being compared, it will be found that the sea water will support a column of fresh water at a higher level. Instead of the metal bend, a piece of indiarubber tube can be used, and by pinching it the waters will not mix when filling the tubes.

Another instrument for comparing the relative weights of liquids is termed a hydrometer. One is shown by Fig. 643, and can be bought for about one or two shillings. The upper portion is a glass tube having a scale inside. At the bottom is an enlargement containing air to act as a float, and below that a

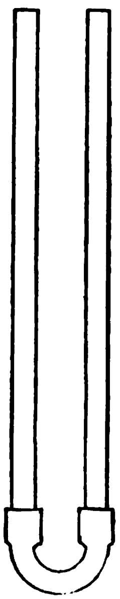

FIG. 642.

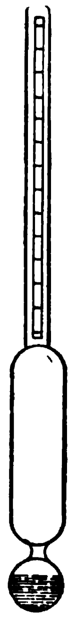

FIG. 643.

bulb containing mercury. The scale is divided and marked so that comparisons can be made. When immersed in a vessel of pure water it will sink to 1,000 on the scale. If a lump of salt is added to the water the hydrometer will be found to rise as the salt dissolves, thus practically demonstrating the difference in density of the two kinds of water. If oil or spirits are being compared the instrument will sink deeper than in water.

Another physical property of water in its natural state is its inexpansibility and incompressibility. Although water can be expanded and compressed, it is to such a small extent that, so far as we are interested, it can be entirely ignored. At the present time we have many illustrations of the value of this property in the number of machines, cranes and similar appliances which are in everyday use and worked by water pumped into pipes by machinery some distance away. If water were an elastic fluid it could not be so easily utilised for this purpose.

Water has inertia, that is, has no power of motion in itself or power to stop when in motion. When we open a cock and allow water to flow out of a vessel or pipe the motion is caused by gravitation or the natural force by which the earth attracts all bodies to itself, and not by any power of its own. And, again, when we open a cock, attached to a length of pipe, for water to flow out and then suddenly close the cock a loud rattling noise is heard, and this is caused by the inertia of the water being overcome by the walls of the pipe. To stop these noises we have to gradually check this inertia by the aid of an air vessel, the air in which acts as a buffer for the water to knock against, as stated in an earlier lecture.

Water and all fluids always have their exposed surfaces in a state of equilibrium or, as we say, level. That is, the surface of the water is at right angles to an imaginary line drawn to the centre of the earth. The surface is not a straight line as proved by the oceans which take the rotundity or roundness of the earth. Because of this equilibrium we can fill our cisterns from reservoirs at a distance, if they are level with or higher than the cisterns. Springs of water rise above the ground in the endeavour to be level with the source or reservoir from which they are fed.

If a glass vessel is made as shown by Fig. 644 and filled with water, the latter will be seen to stand level in all the connections no matter what shape they may be or how much they may hold, provided they are open at the top to let

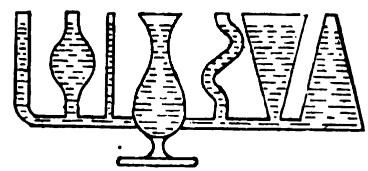

FIG. 644.

out the air. If a number of cisterns are fixed on the same level, that is the tops of the cisterns, and coupled together, they would all fill to the same level, but if one or more are fixed lower then the others, the higher ones would only partially fill, the water rising to the same level as in those lower. When cisterns are fixed on the various floors of a house and fed from a tank on the roof, or a reservoir at a distance, a ball valve must be fixed to each cistern to shut off the supply, otherwise they would overflow or the water run to waste.

Another physical property of water is its solidifying, or being converted into ice, on being subjected to intense cold. At a temperature of 32 degs. Fahr. this phenomenon takes place. Pipes and other closed vessels are frequently

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burst by the contained water freezing. On solidifying, the water expands from 8 to 10 per cent. That is, 100 cubic inches of water will increase to about 110 inches on being converted into ice. If a lump of ice is placed in a vessel of water it will float. We find this in water courses, lakes, seas, &c., during frosty weather. Bulk for bulk ice is the lightest, and we have an illustration of this in the floating icebergs in the Arctic seas.

A physical phenomenon of water is capillarity or the power of rising in tubes with hair-like bores through them, and also in porous materials having interstices or small spaces no larger than hairs. If two pieces of glass about 4 or 5 inches square are placed, with two of their edges touching, in a tray of water, as shown by Fig. 110 in an earlier lecture, the water will be found to rise between them, as shown by the curved line. Where the glasses are 1-200th of an inch apart the water will rise to a height of about 10 inches, 1-100th in. to 5 inches, and 1-50th in. to about 2½ inches. Water is often found to pass between the laps of lead on a roof by capillary attraction, and to rot the woodwork beneath. This was explained when

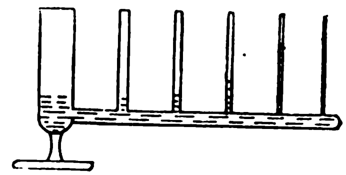

FIG. 645.

writing on roof work. Another model, made of glass, to illustrate capillarity is shown by Fig. 645. The tubes are progressively smaller and of the sizes given above. When demonstrating with this model it is advisable to tint the water with permanganate of potash or other colouring material, otherwise it is difficult to see in the smaller tubes.

HYDROSTATICS, OR THE SCIENCE WHICH TREATS OF FLUIDS AT REST.

WATER exerts pressure, that is, presses against the sides of any vessel containing it. And this pressure is in all directions, excepting at any exposed surface, when it may be said to press against the air. The pressure of water is a known quantity, and depends upon the head or height of the column and not upon the bulk or volume. To make this clear we will first proceed to find out what pressure water really exerts.

We have already said that a cubic foot of fresh water at a certain temperature weighs 62½ lbs. If we could cut up a cubic foot of water into strips 1 in. square and 1 ft. long, on the lines shown by Fig. 646, we should find that each strip weighed ·434 lbs. This is arrived at by dividing 62½ lbs. by 144 in. One of these strips placed on end would exert a pressure of ·434 lbs. on 1 square inch of surface, but if the whole of them could be piled on end, one above the other, they would exert a pressure of 62½ lbs. on the same space. Before the water was cut up it exerted the same pressure, namely, 62½ lbs., but it was spread over an area of 1 square foot, or 144 square inches. In our illustration we have dealt with water as if it had been a solid, and we must now go further and deal with it as a liquid. In the case of a solid, the pressure is in one direction only; in the case of a liquid it is in all directions.

If we fill an open vessel, no matter what is the shape or form, with water, the latter will exert a pressure on the sides of the vessel and escape out of any opening or hole that is made below the surface. If thin pieces of indiarubber were fastened over the holes the pressure of water would cause the rubbers to expand or stretch. If all the rubbers had the same tenacity, and covered holes at the same distance below the water surface, they would

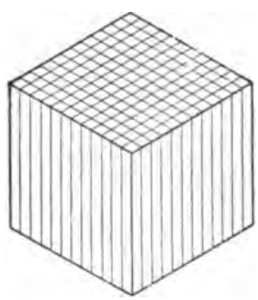

FIG. 646.

stretch to the same extent, but if they were attached at different levels those near the bottom of the vessel would be subjected to a greater pressure and consequently would stretch more than the others. If we make a vessel of a certain depth and attach valves to

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the openings made in the sides, as shown by Fig. 647, on filling the vessel with water it will be found to escape at all the valves, and to prevent such escape weights must be placed upon them. If the vessel is filled to the brim and the valve marked A has a flat surface exposed to the water of 1 square inch, and is fixed 1 ft. below the top, a weight equal to ·434 lbs. would be necessary to make the valve balance the water pressure. Less than that weight would be useless, and a larger must be added if it is desired that no water shall escape. In the figure the dotted lines are supposed to be 1 ft. apart and are level with the undersides of the valves against which the water is pressing. By simple calculation we find the weight to balance the pressure on the underside of valve B must be $2 \times {\cdot}434$, or ·868 lbs., and so on for all the others. The last one, H, being 8 ft. below the surface, we have $8 \times {\cdot}434 = 3{\cdot}472$, or nearly $3\frac{1}{2}$ lbs.

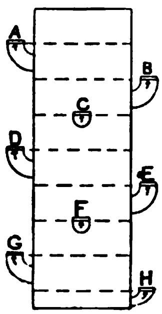

FIG. 647.

The connection to the last valve is near the bottom, but the head of water exerting pressure has to be measured above the surface pressed against.

Not only is this pressure exerted on the valves, but it is pushing against the sides of the vessel to the same degree. Taking the dotted line level with the valve A. This being 1 ft. below the surface, ·434 lbs. are pressing against every square inch inside the vessel at that depth. If the vessel is 6 in. in diameter, and we multiply that by 3·1416, we get 18·85 in., nearly as the circumference. Multiply this by ·434 and we find a belt round the vessel 1 in. wide and 1 ft. below the surface has to resist a told pressure of 8·18 lbs., although only ·434 lbs. are pressing on each single inch of the belt. We may refer to this again when dealing with the bursting of pipes.

If we take a piece of glass tube a few inches long, having one end ground perfectly true, place a disc of glass over the end and immerse it in a jar of water, as shown by Fig. 648, the disc will be held against the tube by the water beneath it, thus showing that water presses upwards. A piece of lead can be substituted for the glass disc, and held up by means of a piece of string through the centre until it is immersed in the jar of water. The tube can be moved up and down in the jar, and the disc will not fall off so long as the upward water pressure is in excess of the weight of the disc. If the

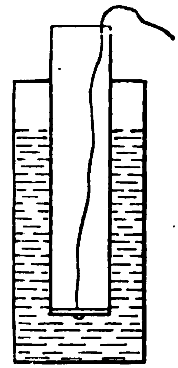

FIG. 648.

latter is made of lead $\frac{1}{8}$ in. thick, and the specific gravity is 11·4, it will be found to fall off the end of the tube if it is raised to within 1·425 inches, or say $1\frac{1}{2}$ in., of the water surface. Advantage is taken of upward water pressure in many ways. It is this property which raises the ball attached to the lever or stem of a ball cock or valve.

A problem in water pressure was given in an earlier lecture. See the text accompanying Fig 395. If we take a bent tube, as shown by

FIG. 649.

Fig. 649, fill it with water, and force a plunger into one end, the water will be forced out at the other. If a tight plunger or piston was placed in the other end of the tube, and loaded with a weight as shown at I, it would be lifted if sufficient power or force was applied to the piston at J, thus showing that the pressure can be transmitted to a distance either short or long, and irrespective of the course the connecting tube may take.

If we have a vessel, as shown by Fig. 650, filled with water, and one foot deep, the total pressure on the bottom, assuming it to be 144 square inches in area, will be $62\frac{1}{2}$ lbs., but the pressure on each square inch will only be ·434 lbs. If the opening at the top is only just large enough for pouring in the water, and for making a rough calculation we assume that it is a point, we have a perfect cone. To find the weight of the contents we multiply the area of the base by one-third of the vertical height and by $62\frac{1}{2}$. The area of the base being one square foot and

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the height one lineal foot, we have $1 \times \frac{1}{3} \times 62\frac{1}{2} = 20{\cdot}8$ lbs., and we find this weight of water exerting a pressure on the bottom alone of $62\frac{1}{2}$ lbs.

If we reverse the vessel, as shown by Fig. 651, and assume that it holds the same quantity of water as the other, and the area of the base one square inch and depth one foot, we then have only ·434 lbs pressing on the bottom against

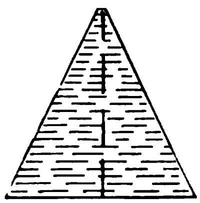

FIG. 650.

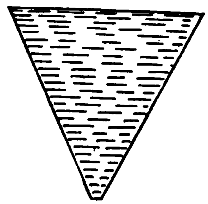

FIG. 651.

$62\frac{1}{2}$ lbs. in the other example, the total *weight* of water being the same in both cases.

To find the total pressure inside the vessels, assume that each vessel is a right cone, the small end in each case being a point. Before making the calculation we must first find the length of the slant side. This can be done by setting out the figure on the drawing board and measuring the length. We will do it mathematically, the rule being based on the axiom, the square root of the sum of the squares of a right angled triangle is the length of the hypotenuse or slant side. If the area of the base of Fig. 650 is 144 square inches the diameter of the circle will be found by multiplying the square root of 144, which is $12 \times 1{\cdot}1283$, and this equals 13·54 nearly. A vertical line drawn from the apex of the cone to the base, as shown by dotted lines Fig. 650, would form one side of a right angled triangle and be 12 in. long. From the bottom of this line to the outer edge of the cone would measure half the diameter of the base and would form the other side of the triangle, and $13{\cdot}54 \div 2 = 6{\cdot}77$.

$$\begin{aligned} \text{Then } 6{\cdot}77^2 &= 45{\cdot}833 \\ \text{and } 12{\cdot}00^2 &= 144{\cdot}000 \\ \hline & 189{\cdot}833 \end{aligned}$$

And $\sqrt{189{\cdot}833} = 13{\cdot}77$ in. as length of slant side.

To find the circumference of the base multiply the diameter by 3·1416. Then $13{\cdot}54 \times 3{\cdot}1416 = 42{\cdot}5372 \div 2 = 21{\cdot}2686$ half the circumference, and $\times\ 13{\cdot}77$ length of slant side $= 293$ square inches nearly, as area of sides.

Although this is the area of the side surface pressed against, the amount of pressure cannot be found by multiplying that by a mean of the pressure, which is half ·434 lbs. per square inch. To illustrate this we can multiply the area by the mean of pressure, and in doing so we find that 293 square inches $\times$ ·217 lbs. $= 63{\cdot}58$ lbs. as the total pressure on the sides This is not so, and to make a more correct calculation, although it is not exactly right, we can divide the sides of the cone into belts of 1 in. wide, calculate the pressure at each inch in depth and multiply by the circumference at such depth. If Fig. 650 is worked out on these lines we find that there is an internal pressure on the sides alone of over 80 lbs. This added to the bottom pressure of $62\frac{1}{2}$ lbs. gives a total of $142\frac{1}{2}$ as the sum of the lbs. pressing against all the sides with which the water is in contact. If Fig. 651 is worked out by the same rule we shall find that the total pressure is considerably below that in Fig. 650, but it is unnecessary to do so here. In either case the total weight of water remains the same, namely, 20·8 lbs.

The student will see from this that *weight* of water and *pressure* of water are two distinct factors, and also the importance of not confusing them together. Plumbers are very interested in this subject as it has a bearing on many parts of their work. The strengthening of cistern sides was dealt with in the lecture referred to above. There is also the question of kitchen boilers, hot water cylinders, water pipes, &c., which must be made strong enough to resist internal pressure when filled with water from a cistern fixed at a higher level. Not only must such fittings be made of good materials and of a good thickness, but their shape or form have to be considered.* As an example, which can be verified by any plumber who has a force pump at his disposal, a lead pipe, square in cross section, is converted into a round pipe by subjecting it to an internal water pressure. Fig. 652 shows by thick lines the section of a square pipe, and by thin lines the form it takes when subjected to such a test. The writer has

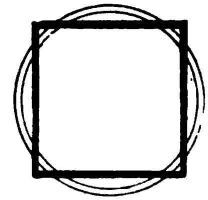

FIG. 652.

several times had a piece of lead soil pipe, bossed up the ends, then jumped upon it with his feet until it was nearly flattened, and then made it resume its original shape by pumping water into it through a half-inch pipe connected to a force pump.

Our last remarks pointed to the conclusion that vessels or pipes of a cylindrical shape are stronger, for holding water, than any other forms.

At this stage it may be considered convenient to deal with the strength or thickness of the materials used for holding or conveying water under pressure. To begin with, we must first know something of the strength of materials and what weight a given thickness or substance will sustain without breaking. Professor Perry

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in his book "Practical Mechanics"* gives a table in which the breaking stress in pounds per square inch of

Lead	is	1,900
Tin	"	4,700
Copper	"	33,000
Wrought Iron	"	50,700
Cast Iron	"	17,500

From this table we learn that bars of the metals having one square inch of sectional area break when subjected to the above strains. As metals vary very much in their quality we may assume the above to be a fair average, and near enough for us to take as a basis for calculations. But we do not want our materials to break, we want them to resist any strain that may be brought to bear, and have to allow a margin for safe working, and the safe working strength varies from $\frac{1}{4}$th to $\frac{1}{8}$th the breaking strength. If we divide the above breaking stresses by four we then have

Lead	475
Tin	1,175
Copper	8,250
Wrought Iron ...	12,675
Cast Iron ...	4,375

and these can, in most cases, be used for calculating the thicknesses of the sides of cylindrical pipes or vessels.

We next have to consider how the pressure acts inside those fittings. From what we have said before we know that the pressure is equal on all sides, as shown by the darts in Fig. 653.

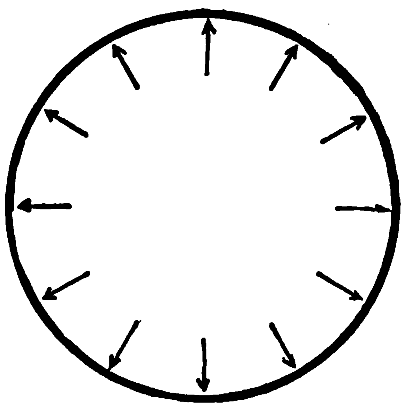

FIG 653.

But the molecules of water are pressing not only against the sides but against each other, so that the tendency is not only to push out the sides but to tear them asunder, as shown by Fig. 654. If we assume that the water is so tightly packed in the two halves of the pipe as to approach a solid in its density, and that a force is applied to thrust the two halves apart, as shown in the figure, we can the better grasp the principles which guide us in arriving at the strength of the materials necessary to resist the action. If we take the surface of the water as being 1 in. wide × the length, equal to the diameter of the pipe, that will give us the area of the surface pressed against in one inch in length of the pipe. This multiplied by the pressure in lbs. per square inch will give the amount of force to be resisted by the sides.

We may work out an example with a 2 in. lead pipe and a pressure of 100 lbs. per square inch. Then 2 in. × 1 in. × 100 lbs. = 200 lbs. total pressure. On referring to the table we find the safe working strength of lead is 475 lbs. per square inch, and by rule of three as 475 lbs. : 1 in. : : 200 lbs. : 0·421 in. This being the total pressure on K and L in Fig. 654. Then ·421 ÷ 2 = ·210 in. as the thickness at K and L respectively.

If we take another example of a 6 in. lead pipe under the same pressure we have

$$\frac{6 \times 1 \times 100}{475} = \frac{600}{475} = 1{\cdot}263 \div 2 = {\cdot}631\text{ in.} =$$

thickness of side of a lead pipe 6 in. diameter for conveying water under a pressure of 100 lbs. per square inch.

If the last pipe was made of cast iron we should have

$$\frac{600}{4375} = 0{\cdot}137 \div 2 = {\cdot}069\text{ in. nearly.}$$

In this case we have a very different material to lead to deal with. Although the thickness worked out would probably be safe for using

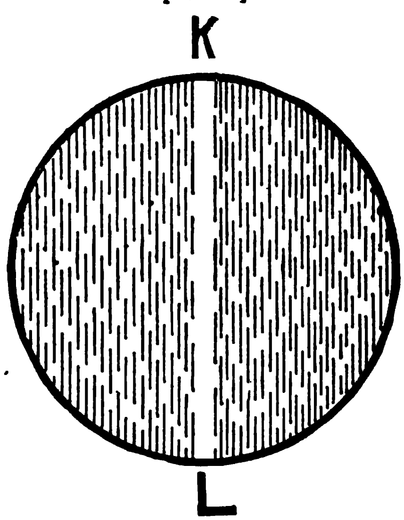

FIG. 654.

under the pressure given it would not do for general use. The joints could not be properly caulked owing to the weakness of the sockets, the evenness of the casting could not be depended upon, and the position, if underground, such that there would be a liability to fracture especially where wheeled traffic passed over. Water hammer caused by the sudden closing of

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a cock sometimes increases the normal pressure four or five times. The thickness of such pipes should not be less than ·42 in., and should be still further increased for greater pressures.

As a further example we may take a copper hot water cylinder. Assuming it to be 20 in. in diameter and is kept filled with water from a cistern 60 ft. above. Then $60 \times {\cdot}434 = 26{\cdot}04$ lbs. pressure on each square in. exerted by the water. On referring to the table we find the safe working strain on copper is 8250 lbs. per square inch, and for the thickness of the material for a cylinder we have

$$\frac{20 \times 1 \times 26{\cdot}04}{8250} = \frac{520{\cdot}8}{8250} = {\cdot}0631 \text{ which} \div 2 = {\cdot}0315 \text{ in.}$$

or say 3-64th of an inch. In this case, too, we have to take other factors into consideration. A cylinder made of sheet copper of the above size and thickness would resist the bursting pressure given, but would not be strong enough to support its own weight and the contained water.

When cylinders have rivetted seams the metal should be thicker than would be actually necessary if they could be made out of a solid drawn tube without seams. We have also to consider the connections and the strain upon them by the movement of the pipe attachments. The metal, too, loses some portion of its strength when heated. For these reasons copper hot water cylinders are not usually made of lesser thickness than twice the above, and for best work much thicker metal is used. For greater heads the thickness should be increased still more.

When dealing with wrought iron as a material for hot water cylinders, the safe strength given in the table would not be at all adequate, the metal being subjected to the corrosive action of water. It is not usual to use plain iron for this purpose, not only because of the above action, but also on account of the discolouration of the water with iron rust. Even galvanising the iron is not always a protection. In one of the writer's experiences the zinc coating of the cylinder and circulation pipes entirely disappeared in about one year from fixing. In such cases copper is the best material to use, but in London galvanised iron answers fairly well. The statement is sometimes made that galvanising iron does not injure it or lower its tenacity. But experiences in working pipes so protected leads the writer to think that it does sometimes injure the pipes, or the latter are made of inferior iron when intended to be so treated.

At all events, when calculating the strength of such pipes and cylinders, I consider a margin should be allowed for deterioration by galvanising. To find the thickness of galvanised wrought iron for a cylinder of the same size and to resist the same pressure as the last one, we may make an allowance on the breaking stress given in the table and divide it by 5 instead of 4, which will give us 10140 instead of 12675 as in the second, or safe working, table. Working on this we have

$$\frac{20 \text{ in.} \times 1 \text{ in.} \times 26{\cdot}04 \text{ lbs.}}{10140} = \frac{520{\cdot}8}{10140} = {\cdot}0513 \div 2 =$$

·0257 in. nearly, or about 1-32nd of an inch. In practice galvanised hot water cylinders are never used so light as this for the same reasons that were given for those made of copper. The writer has never used less than ⅛ in. plate, and frequently, for best work, 3-16th in. and ¼ in. plate.

When we come to deal with any of the above materials in the form of rectangular cylinders or boilers having flat sides, the thicknesses have to be considerably increased, as not only tenacity, but stiffness has to be considered. With boilers, the side next the fire is not only subjected to a corrosive action of the fire, but also to being bruised when throwing in the fuel, or by the tools used when stoking. For these uses the materials should be double the thickness of those for round cylinders, and in some cases treble the thickness would not be too much where really good, substantial work is desired.

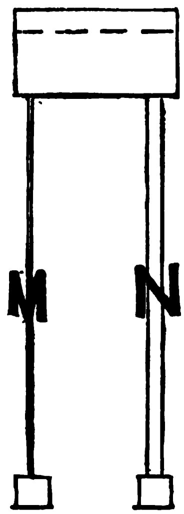

FIG. 655.

Having so far dealt with strength of materials to resist water pressure, we will refer to a few problems to further illustrate our subject. A great many people find a difficulty in understanding that head of water, and not size of pipe, has to be considered when deciding upon the strength necessary for a kitchen boiler. This is especially referred to because of the number of questions submitted by students to teachers on the subject. Briefly put, the question submitted is : "Would a boiler filled with a ½ in. pipe (as shown at M, Fig. 655) be subjected to the same pressure as if a 6 in. pipe were used as at N, assuming that the boilers are at the same level and fed from the same cistern?" The same problem in another form

is generally spoken of as the Hydrostatic Paradox, and illustrated in text books by a large and small pipe being connected at the bottom ends in the form of a U. On being filled with water it will be found to stand at the same level in both pipes, although the water in one may weigh several pounds, and in the other only a few ounces, thus showing that the larger and smaller volumes balance each other, and the smaller is not pushed to a higher level than the other. From this we learn that the pressure of a fluid upon any surface depends upon the area of the surface pressed against and the perpendicular height of the fluid, and not upon the bulk of the fluid. In the case of the boilers, Fig. 655, the pressure per square inch is the same in both. If the cistern was taken away and the pipes M

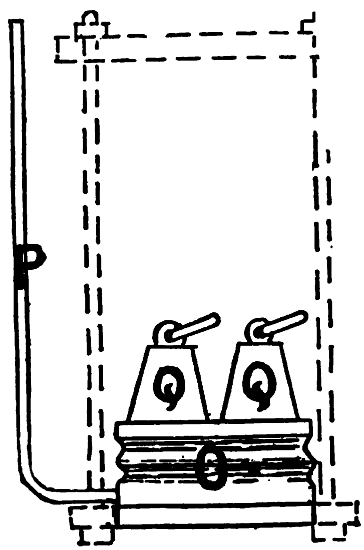

FIG. 656.

and N continued to the dotted line, which is supposed to be the water level in the cistern, and filled with water by means of a jug or can, the pressure inside the boiler would be exactly the same as at first. As a further illustration, we may explain the principle of what is known as the "Hydrostatic Bellows." Assuming that O, Fig. 656, consists of two discs of wood or other solid material, joined at the edges with leather or other flexible material, strong enough to resist being torn by an internal water pressure, and having a pipe attached, as at P. For every foot in vertical height of P, a pressure of ·434 lbs. on each square inch of the inner surfaces of the bellows is exerted when the whole is filled with water. If the inside area of the disc forming the upper part of the bellows is equal to 100 square inches and the pipe P is 10 ft. high, the diameter of the pipe being ¼ in., or any other size, as this makes no difference in the result, the weights Q Q would be lifted if they did not exceed 434 lbs. This we find by the rules. Area of disc × lbs. pressure on each square inch. Then $10 \times {\cdot}434 = 4{\cdot}34$ lbs. pressure per square inch. And 100 square inches $\times\ 4{\cdot}34 = 434$ lbs. representing the weights Q Q, which just balance the pressure exerted. By having the pipe P of a small size and the top and bottom of the bellows almost touching when empty, the whole quantity of water used would probably amount to only a few pints, and as each pint weighs 1¼ lbs., it can be readily understood why the problem should be looked upon as being paradoxical.

Where water is supplied from a reservoir at a very high level the pressure can be, and is sometimes, utilised for some useful purpose. Taking Fig. 656 as an example. If a strong frame was constructed over the bellows, as shown by dotted lines, and the weights removed, a hydraulic press would be formed, and could be use for compressing goods for packing. Such presses are used in shipping warehouses where large bales of goods are reduced in bulk for carriage or shipment. Trusses of hay and straw can be reduced in size by the same means. For work of this kind the flexible material used in the manufacture of the bellows would not be strong enough to resist a great pressure, and in addition, would soon wear out by constant use, or become weakened by the decay of the material. For these reasons presses are usually made of very strong materials, or metals, and mechanical appliances used for generating the water pressure where that from a reservoir is not available or is insufficient.

Water pressure is utilised by the plumber, or lead burner, for the supply of air when using the aero-hydrogen blow-pipe for joining lead together. One example of this machine was illustrated in an earlier lecture (see Fig. 11). That used by the students at the Polytechnic school of plumbing is shown in section by Fig. 657. The outer case is round on plan and made of galvanised sheet iron, or stout zinc, and has a division, R, with a pipe, S, continued nearly to the bottom of the case. Water poured into the opening, T, runs down the pipe and compresses the contained air in the lower half of the machine. To this is attached a small pet cock, U, and an indiarubber tube from the latter leads to the breeches piece of the flam or jet used for lead burning. When all the air has been used more is forced in by the double acting pump, V, which is attached to the side of the machine. On pumping in more air the water is forced out of the lower into the upper half, as shown in the figure, and thus exerts a pressure on the confined air, which is sufficient for the purpose of the plumber and the work he has to do. The machine is sometimes called a "water bellows" and is much better than the old-fashioned air bellows in that the pressure is more constant and even, and a steadier flame can be obtained. There is also less liability of any hydrogen gas being sucked

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into the bellows through any defect which may arise in the valves or manipulation of the cocks, but does not do away with the necessity for closing the latter when ceasing working.

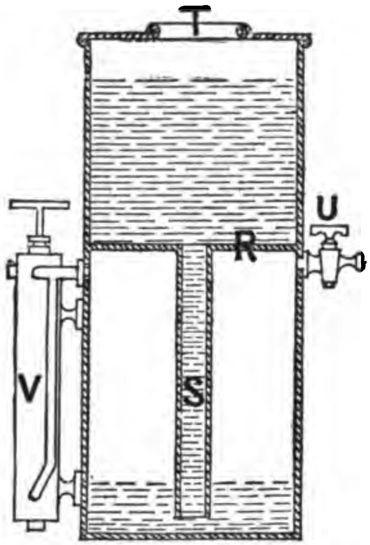

FIG. 657.

By the aid of machinery water can be made to exert a pressure which is only limited by the strength of the materials used for the purpose of confining it. A very good illustration of this is found in the modern lead pipe-making machine. In this the initial pressure is multiplied to an enormous extent. The pumps for generating the pressure are called "force-pumps," and have solid plungers or pistons For pipe making it is important that the hydraulic pressure should be constant and even, and to this end it is usual to have three pumps worked from the same shaft, the cranks on which are reciprocal to each other. By this means one of the three pumps is always forcing water into the pipe leading to the press. A lesser number would not act so well, as the issuing stream would vary according to the position of the stroke. With ordinary pumps an air vessel would be used to get a more constant and even delivery, but in the case we are dealing with such an attachment would not work well, even if made strong enough to withstand the pressure. The construction and power of pumps will be described under our next heading of "Hydraulics," and we will confine ourselves for the present to the power exerted in a lead pipe press or machine.

In one large works, visited by the writer and students attending his classes, it was noticed that the pressure on the service to the machine, as registered on the gauge, was 2,240 lbs, or 1 ton on the square inch. One of the pipe presses was of the shape shown by Fig. 658. At W, is an opening through which the lead is forced in the form of a pipe, a pit being below for its escape; X is a massive iron casing into which lead is run from an adjoining melting pot; Y is a piston or plunger 6 in. diameter, and Z is a copper or gun-metal ram, 18 in. in diameter, forced downwards by the hydraulic pressure of 1 ton on the square inch, as above mentioned, the force being exerted on the end A. To find the total pressure on this end we use the rule, area of end of ram in inches × pressure per square inch = total pressure. To find the area, square the diameter and × ·7854. Then $18 \text{ in.}^2 \times \cdot 7854 = 254\cdot 4696$ square inches, and this × 1 ton pressure per square inch = 254·4696 tons forcing the ram downwards. This force is exerted in pushing the lead out of the die W, and if we divide it by the area of the end of the piston we find that $6 \text{ in.}^2 \times \cdot 7854 = 28\cdot 2744$ square inches and $254\cdot 4696 \div 28\cdot 2744 = 9$ tons, as representing the pressure on each square inch of the end of the piston pushing the lead downwards. This shows one method by which a low pressure of water can be made to exert one much higher. The problem was worked out as above to make the matter clear. A shorter method would be to divide the area of the end of the lower piston into that of the upper, as follows:—$18^2 \div 6^2 = 324 \div 36 = 9$, this representing the number of times the pressure per square inch on the upper surface is increased on that of the lower one.

If the engines and pumps were kept working when the pipe press was not being used, the resistance would either stop the pumps or some part of the machinery would burst or otherwise break down. To prevent this catastrophe, a safety valve, very similar to that in steam boilers, is attached to the delivery pipe from the pumps. Should the water pressure become excessive the safety valve opens and affords relief. In some works the—what we have termed—safety valve is connected by means of gearing to a throttle valve on the steam pipe to the pumps, so that the steam is automatically shut off and the pumps stopped whenever the pressure in the water pipes is more than necessary or runs up too high owing to the stopping of the pipe press or any other cause.

Mention has been made of the importance of the pressure on the ram of a pipe machine being constant and even. Because of this, and also to conserve and store up any energy that would otherwise be wasted, an arrangement known as an "accumulator," is attached to the pipe from the pumps to the lead pipe press. This is shown on the left hand side of Fig. 658. If the man at the machine has occasion to cease working, he turns off the cock at B, and the pressure is then expended in pushing up the piston, C, in the cylinder. On the top of the piston is a frame, or head piece, D, from which is suspended a box loaded with stone or other weighty material, E E, with guide posts for preventing swaying from side to side and straining the piston. The load is proportional

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to the area of the piston end. As an example, if the water pressure in the pipe, F, is equal to 1 ton on the square inch and the area of the piston end 20 square inches the load would be 20 in. × 1 ton = 20 tons of stones or weights suspended from D. By the use of an accumulator the pressure in the water pipe is kept constant. If the pumps were stopped for a short time for any necessary purpose, and the accumulator was fully charged, the pipe press could be kept working until the stored energy was exhausted. In any of the above calculations no allowance has been made for friction, or weight of piston and other parts, as it is not necessary for our purpose of explaining what hydraulic pressure means.

The hydraulic press is known to many as, and is frequently called, "Bramah's" press. What has been described above in the pipe making machine, and in reference to Fig. 656, explains the principles, but it may be interesting to refer to another use to which Mr. Bramah applied the same machinery. In 1797 he took out a patent for various inventions, including one for making lead pipes. Fig. 659 is a sketch repeated from my book "Plumbing Practice," and which was originally copied from Mr. Bramah's specification for the patent. Little description is necessary, beyond referring to the various parts. It will be noticed that lead is forced out of the die by the pressure of the piston actuated by a lever. The parts are as follows: A A is an iron melting pot; B an iron or brass pump; C a suction valve; D the mould or die; E the core or mandrel; F the fire; G G are flues; and H is the pipe as it issues from the nozzle of the mould. The whole machine being really a very strong pump for forcing liquified lead out of an opening in the form of a pipe or tube. There are some doubts as to Mr. Bramah's being able to make lead pipes by this machine, but it is a good example for illustrating the power we have been dealing with.

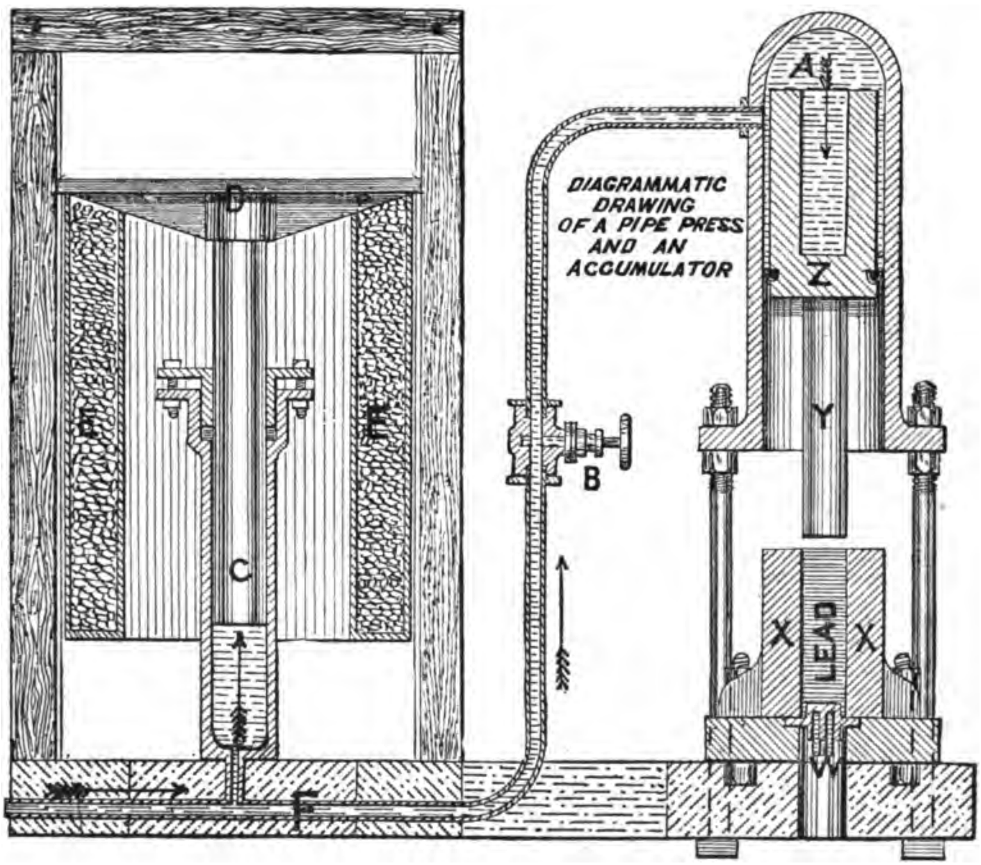

Fig. 658.

During the last few years a great many lifts have been fixed for raising goods from floor to floor in warehouses, and passengers in hotels, &c. Fig. 660 is an illustration of one kind of

lift, the guides and safety appliances being omitted. The parts are as follows: E is a cage or box for goods or passengers; F is a piston which slides in a tube or cylinder, G, sunk in a boring in the ground and suspended on trunnions or arms, H; I is a counterbalance with chain or wire cable over loose pulleys, J J, to the cage; and K is a specially constructed valve with wheel head and actuated by the ropes, L L. On pulling one of the ropes

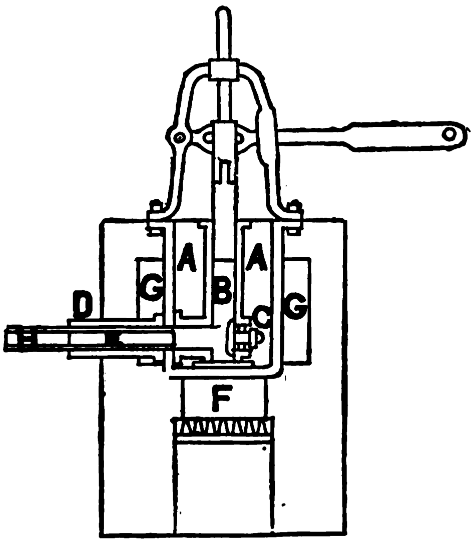

FIG. 659.

the valve is opened, water under pressure passes into the cylinder and forces up the piston. On pulling the other rope the valve shuts off the water and the motion of the lift is stopped. On further pulling the rope the valve is opened to allow the imprisoned water in the cylinder to escape and the lift to lower. The counterbalance is not quite equal to the weight of the cage and piston. If the former is too heavy, the latter would not lower when unloaded. To find the hydraulic pressure necessary for raising a load in the cage, we must first know what the maximum load will be. If we assume that it is half a ton, and the difference in weight of cage and piston and the counterbalance 5 cwt. in favour of the former, we then have to deal with a total weight of $\frac{3}{4}$ ton or 1,680 lbs. If the piston is 4 in. in diameter we find the area thus: $4^2 \times \cdot 7854 = 12\cdot 5664$ square inches. If we divide the 1,680 lbs. by 12·5664 square inches we find that 133·6 lbs. hydraulic pressure per square inch must be exerted from the main pipe or pumps to push up the piston, F, and the loaded cage, E.

In some cases where the pressure from an ordinary water company's main is fairly regular, but does not exceed 40 lbs. or 50 lbs. per square inch, it can be utilised for a lift constructed on the same lines as Fig. 660, but the size of the piston must be increased. As an example, if the load to be lifted is 1,680 lbs., as in the last case, and the pressure from the main is only 40 lbs. per square inch, what should be the diameter of the piston shaft? The weight of 1,680 lbs. $\div$ 40 lbs. pressure per square inch = 402, the number of inches in the end of the piston. The square root of this $\times$ 1·1283 will give the diameter of the piston, and

$$\sqrt{402} = 20\cdot 05 \text{ nearly} \times 1\cdot 1283 = 22\tfrac{1}{2} \text{ in.}$$

A piston of this diameter would be very heavy, even if hollow, and the counterbalance of such a weight that it would require a massive

FIG. 660.

framework to support it. Theoretically, such a lift could be constructed and would work, but it is not one that would be adopted in general practice. Small ones for light loads, such as dinner lifts, are frequently fixed in mansions, but as they are rather slow in action ordinary hand hoists are more common for such purposes. Hydraulic lifts worked from water company's mains are sometimes used in banks in London for hoisting books from the strong rooms to the offices, and in warehouses for goods from basement to ground floor.

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Another kind of lift is much used where the water head is sufficient to work it, such as from a high pressure hydraulic main, for hoisting and many other purposes. Fig. 661 is an illustration of a lift raised by means of a chain or

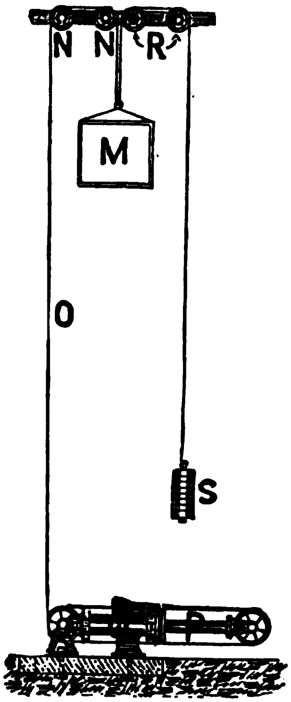

FIG. 661.

wire cable wound round pulley wheels fixed at the ends of a piston and cylinder respectively. Hyraulic pressure inside the cylinder forces the piston out and the pulley wheels further apart, thus shortening the hoisting part and raising the load. By this application of water pressure speed is gained at the expense of loss of power. The working parts are as follows: M is the cage or load; N N are pulley wheels; O is the chain or wire cable; P is the piston; Q the cylinder; R the counterbalance pulleys; and S the weight. Before we can work out the water pressure necessary to raise a given load we shall find it an advantage to spend a short time on the power gained by multiplication of pulleys.

This is not the time to deal extensively with the mechanical powers, and we will confine ourselves to what plumbers call a "double reeved block and fall," as ordinarily used for hoisting. Let Fig. 662 represent the appliance, W being a weight to be lifted, and P the power applied to raise it. The rule in mechanics for finding the power is to divide the weight by the number of cords passing over or round movable sheaves. In our case we have two moving upwards and two downwards, the loose end leading to P being only equal to that leading up to the block, or four in all. If W weighed 400 lbs. and we divide that by four, the number of cords, we have 100 lbs., and that represents the weight or power at P to balance W. If we were to take friction, and the stiffness and condition of the ropes, into consideration, we should have to make an allowance for that and add about one-sixth to one third of the weight to P when dealing with such appliances in the condition as when used on buildings. When P is heavy enough to raise W, the latter will travel at one-fourth the speed of P and pass through one-fourth the distance.

If we reverse the problem we find that W will raise nearly one-fourth its own weight at

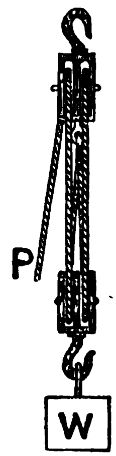

FIG. 662.

P, which would travel four times the distance at four times the speed.

This being clearly understood we can now the better deal with the lift or hoist shown by Fig. 661, and work out a problem.

If we assume that M represents a load of one ton, then a pull of one ton must be exerted on the chain or cable O, which passes four times round the pulleys of the hydraulic cylinder, this being bolted or anchored down to resist being lifted by the strain on O. If we know the pressure of the water supply to the cylinder we can then calculate the required area of the ram or piston end, or *vice versa*. If the pressure equals 500 lbs. on the square inch and we divide that into M, we first get 4 tons $=$ 8,960 lbs., and divide this by $500 = 18$ nearly square inches and $\sqrt{18} \times 1{\cdot}1283 = 4{\cdot}787$ or just over $4\frac{3}{4}$ in. as the diameter of the piston P. If, as another example, we had a piston 6 in. in diameter to work the same load we should have $6^2 \times {\cdot}7854 = 28{\cdot}2744$ square inches, and divide this into $8960 = 317$ nearly lbs. of water pressure on the square inch to balance the load of one ton at M.

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Or if we have a 5 in. piston and 600 lbs. pressure on the square inch we get $5^2 \times \cdot 7854 \times$ 600 lbs. = 11,781 lbs., or 5 tons 5 cwt. 0 qr. 21 lbs. as a power at P, which $\div$ by 4, the number of cords would be equal to 1 ton 6 cwt. 1 qr. 5 lbs. or the weight supported at M.

In the above examples the load and power have been worked out to balance each other, but to do useful work the power must always exceed the work to be done. In addition an allowance has to be made for friction and weight of working parts. The examples taken were not intended to illustrate hydraulic machinery, but, as before explained, to help the student to a clear understanding as to what hydraulic pressure really means and its application to some useful purpose.

It will further help our purpose to refer to the action of the same force in nature. One of the commonest examples is what is known as "land slips." Any one who travels much on some of our railways has no doubt some time or other noticed when passing through cuttings that the banks have slipped in. This has frequently been caused by an accumulation of water, in the land, which has destroyed the tenacity of the earth or exerted sufficient pressure to force away a slice. On many lines very strong brick or stone walls with buttresses have been constructed for the purpose of preventing such slips, but a careful observer will have noticed that small drain pipes have been built in the walls, so that if any water should accumulate behind them it would find an outlet and drain away. But for these provisions they would be pushed away, unless they were built much stronger, in which case they would cost considerably more.

Cliffs, near the sea, which are waterlogged, are frequently pushed away from the main land by the same force.

Many of our hills have probably from time to time had pieces pushed off in the same way. Fig. 663 will help to explain how the action may occur. Assuming it to represent a large hill or a mountain. Some parts being covered with trees, the roots of which help to bind the surface together, very little action takes place, but on those parts which are exposed to heavy rainfalls and have a very porous surface, the water soaks in and the ground becomes so charged that it may be looked upon as an underground reservoir. The horizontal dotted lines are intended to show water saturated land Springs are frequently found on the sides of such hills, and as these springs discharge water,

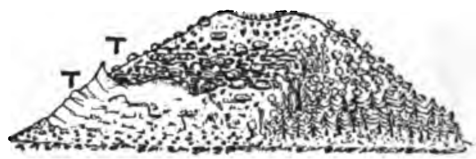

FIG. 663.

sometimes several months after any rainfall, it must come from somewhere, and that place is the hill itself. If the ground on the top of the hill is of an open absorbent nature, and the base not so, an enormous hydraulic pressure is exerted inside, or beneath the ground surface whenever it gets waterlogged and the water cannot get vent in the form of springs or some other way. The writer knows of places in his native county where large fields of grass land, several acres in extent, have some portion or other of their parts constantly sliding downwards. If the student cares to take the trouble he can calculate the number of tons of hydraulic pressure exerted beneath the surface of an acre of land with only one foot head of water confined beneath.

In the case of a mountain, as shown by Fig. 663, where rocks or stone form a portion as at T T, and the water cannot escape freely at the lower level as it is absorbed in the upper, an enormous volume accumulates and thrusts outwards at all parts. Should these rocks have cracks on the surface and any water get into them, the latter, when frozen, would expand and thus enlarge the cracks. Repetition year after year would so weaken the whole, or a considerable portion, that the pent up water would be sufficiently powerful to thrust away a large piece of the mountain, as shown by the projecting pieces on the left side of the figure. It is true in nature some of these pieces are not thrust away as explained above, but are cut off, so to speak, by small streamlets, which wear away any soft parts and give the appearance shown. Some kinds of soil, as sand, "flow" with running water. Nevertheless hydraulic pressure plays a considerable part in altering the appearance of the surface of the earth.

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EXPANSION OF WATER.

BY expansion an increase of volume is understood. In the case of water this takes place either by heat or extreme cold. The word cold is used only as a comparative term, and is considered as heat at a very low temperature. Cold is not a definite term and is only used to convey the sensation felt on changing from one temperature to another lower in the scale. A homely illustration is an experience of the writer's when bathing in the open air in the summer time. When plunging into the water in the early hours of the morning there has been a sensation of warmth, but a bath taken at, or after, noon on the same day in the same water a decidedly chilly feeling has been felt. The temperature of the water was the same in each case, but there were several degrees difference in that of the air at the times when the baths were taken. The air in the morning being colder than the water, and at midday the latter the coolest, the sensations were reversed. At the seaside, early bathers are noticed to dress as quickly as possible after their dip, but later in the day, if fine and opportunity presents itself, they will gambol on the beach and revel in the warmer air before dressing. Plumbers working in a deep well will experience a sense of cold when going down during warm weather, but of warmth in the winter time. A piece of metal at a temperature of about 60 degs. Fahr. will feel cold to a person whose hands are warm, and the opposite to one who has cold hands. From this we find that warmth and cold are only comparative terms and cannot be used in the same sense as heat and temperature. The latter can be measured and described in such terms as to be easily understood. For measuring heat, an instrument called a "Thermometer" is used for both air and liquids. That for the latter has a larger range than for air as the extremes of temperature are further apart.

Fig. 664 is a sketch of a thermometer used by brewers in taking the temperature of the water and "worts" when brewing and when fermenting beer. The case is made of tinned iron or copper with a face plate, which is divided into spaces called degrees, and on which is marked the temperatures of various matters of common interest. The divisions are what is known as Fahrenheit's scale. In the centre of the instrument is a glass tube U, the top end of which is hermetically sealed. At the bottom end, V, is attached a small glass bulb, shown by dotted lines, containing mercury, this metal in a fluid condition being found the best of all liquids for this purpose, as it expands and contracts in a nearly equal proportion for the various degrees of heat and extends over a wider range than any others. The lower part of the case forms a cup for retaining a portion of the liquid, when taking temperatures, until the reading has been noted, but the instrument should be totally immersed for a short time previously, otherwise it will not register correctly.

At every change of temperature water either increases or diminishes in bulk or volume, and the point of greatest density is 39·2 degs., or say 40 degs., Fahr. Even one degree change from this either way causes the water to expand, and the specific gravity varies with the amount of expansion. As an example, 1 cubic foot of water at 40 degs. Fahr. weighs 62·425 lbs., and at 212 degs., or boiling point, only 59·832 lbs., or 1-24th less. Or we may take it that a cubic foot of water, or 6·25 gallons at 40 degs. becomes 6·51 gallons at 212 degs. Because of this expansion it is always necessary to fix the

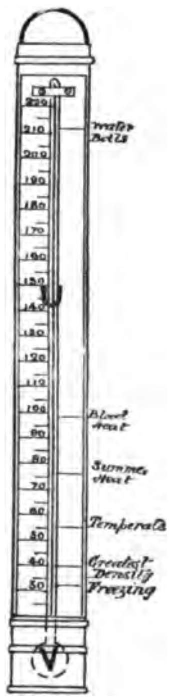

FIG. 664.

overflow pipe of a feed cistern to a boiler so that the latter cannot overfill, and also to regulate the ball valve so that the water is some distance below the overflow to allow for swelling.

In the case of a feed cistern to a heating apparatus, the cistern has to be large enough to hold the whole of the excess caused by expansion. Referring to Fig. 665, W is the level of

the water when cold, or say at 58 degs., and X the height to which it will rise when hot, or say about 190 degs. To work out an example we may assume that a boiler, circulation pipes, and feed cistern filled to W, holds 500 gals, the water being at 58 degs. Then 190 degs—58 degs. = 132 degs. to which the water will be heated. If we take ·0000 degs. as water at its greatest density,* at 58 degs. as having

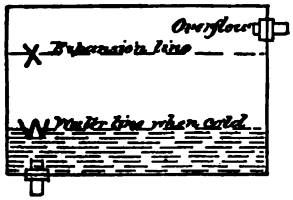

FIG. 665.

expanded to ·00076, and at 190 degs. to ·03501, then ·03501—·00076 = ·03425 and this × by 500 gals. = 17·125 gals. the total expansion. The space or capacity of the feed cistern between W and X should be equal to that quantity of water. This is an approximate calculation for practical working. To be exact, the holding capacity of the pipes and the boiler when expanded by heat would have to be considered and an allowance made.

Having dealt with expansion of water by heating above ordinary temperature (not that the subject has been exhausted or very high temperatures dealt with), we may now consider the same phenomena at low temperatures.

We have already stated that water is at its greatest density at about 40 degs. Below this it expands, in almost but not quite the same proportion as above, until the temperature of 32 degs. in reached. This is called the freezing point of water and the melting point of ice. When water is kept perfectly still the temperature can be further reduced before congelation takes place; but if the least motion is given to it, it solidifies at once and expands with considerable force, sufficient to break or burst any vessels containing it. The weight of a cubic foot of water at 32 degs. is 62·38 lbs., but a cubic foot of ice at the same temperature is only about 58 lbs. This difference, which shows increase in bulk, taking place suddenly, will help to explain the phenomena of pipe bursts. Many people think that it is the thaw that sets in after freezing that breaks the pipes, but it is not so. It is the expansion of the water converted into ice that does the damage, but it is not always discovered until the thaw sets in.

Many interesting problems present themselves to plumbers during frosty weather, and if they were carefully noted would impress themselves on the mind more than reading books on the subject. It is only reasonable to suppose that people's experiences vary, and that the conditions under which observations are made are not always the same. Neither are the same deductions drawn by different people from the same illustrations. The writer has noticed that with cast-iron water mains, pieces are burst or pushed off by the expansion of ice. Wrought-iron pipes vary very much. Some have had slits only 3 in. or 4 in. long opened in the sides, whilst others have had them as much as 2 ft. long. In some cases, what is known as "steam barrel," which has resisted the pressure the longest, has been torn more than a lighter pipe, such as is generally fixed for conveying gas but has been used for water. Lead pipes, too, vary very much. Some have been noticed which did not burst, but had enlarged portions, or swellings, but the generality of such pipes burst with from ½ in. to 4 in. long openings, lengthwise in the sides, but never across the pipe. Ice expands equally in all directions, so that the greatest thrust is in the line of the longest dimension. This is demonstrated by the fact that more frost bursts occur at branch joints than anywhere else in the pipes. Fig. 666, is an example of a ¾ in. pipe which had ½ in. branches leading to the valves exhibited in action in a manufacturer's show room. Under each branch joint, as shown by the figure, a burst occurred, but none of the other pipes in the same room were affected, although of the same strength or thickness, exposed in the same manner and under the same head of water. Interested friends suggested that the soldered joints, being stronger than the pipes, prevented

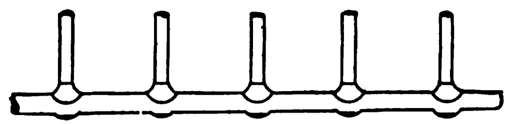

FIG. 666.

uniform expansion, and thus concentrated the whole of the force on the points indicated. The writer held a different view and took an early opportunity of trying an experiment. This he did by soldering a disc of lead in the end of a piece of ¾ in. lead pipe, filling the pipe with water and then closing the other end by pinching it in a bench vice, afterwards copper-bitting the edge of the pinched end. On freezing, the whole disc of lead was rendered convex outside and eventually torn from the soldering, and the pinched end partly resumed its cylindrical shape.

From time to time the writer has made many experiments by exposing colourless glass bottles partially or wholly filled with water to the action of frost. When partially, or about half-filled, they have remained intact, but he has noticed in some instances that in the early morning the water has entirely been converted into ice. On afterwards making another examination, when the sun was shining, he has found the surface of the ice inside melted to

* Clarke's Tables.

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the depth of about ½ in., but the upper portion of the bottle was lined with beautifully arranged ice crystals. Unless some change took place during his absence and of which he did not know, the conclusion to be drawn is that the sun's heat rays passed through the glass and melted some of the ice. The vapour arising from the water so formed condensed inside the upper portion of the bottle, which was exposed to the cold air, and again froze in the form of hoar frost, but this did not intercept the sun's rays or prevent them thawing the ice below, and keeping it in a liquid condition. With a view of finding out more about the expansion of ice, several bottles were filled with water and corked, some loosely and others tightly, with varying quantities of air betwen the water and the corks. Other bottles were left open instead of being plugged.

Fig. 667 shows examples of two out of several that were placed in the garden about 10 o'clock on the evening of February 4th, 1895, the sketches being made about 9 o'clock on the following morning. The bottle A was filled to overflowing, and the cork forced in so as not to

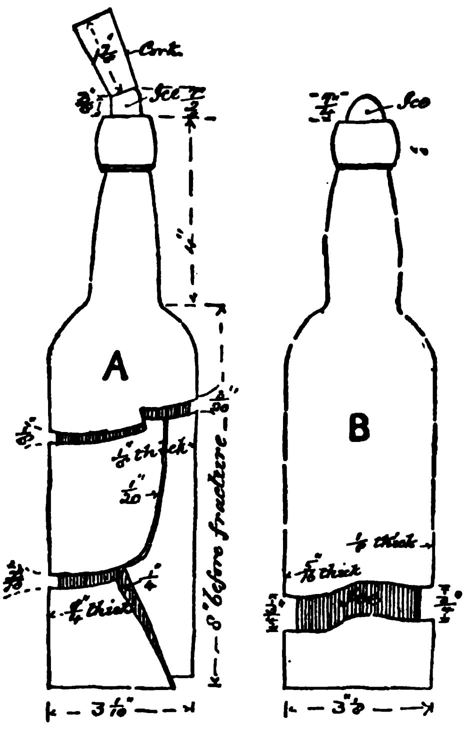

FIG. 667.

leave any air between it and the water. The dimensions are all marked on the figure. Everything tends to prove that the expansion is greatest on the line of the longest dimension. The cork was forced out of the neck and had nearly ½ in. of ice showing between it and the bottle. The former had only ⅜ in. projecting when first forced in, and as it was 1⅞ in. long it had travelled upwards 1⅝ in. from its original position. The upper portion of the bottle was not broken in any way, but there was a zig-zag fracture all round at an average of 2⅜ in. below the neck. The opening was ⅛ in. on one side and 3-20 in. on the other. Below this a vertical crack 1-20 in. wide ran down to another one 2-10 in. wide, extending about two-thirds round the bottle and then in a slanting direction to the bottom. The thickness of the glass varied very much, in some parts being under ⅛ in. and others over ¼ in.; the quality being clear glass, as usually sent out by spirit merchants. The thick parts appeared to offer no more resistance than those which were thinner.

The bottle B was filled to the top and was left uncorked. The ice projected ½ in. above, the centre being so very convex as to lead to the impression that the inner parts travelled faster and further than those in contact with the side of the neck of the bottle. On making further and later inspections it was noticed that the ice, during the daytime, kept expanding as the cracks were slightly more opened in both bottles. It also projected more above the necks in each case, but evaporation was taking place. Although the cork on bottle A was higher, the diameter of the supporting neck of ice had decreased. On bottle B the centre of the projection was higher, but the diameter had decreased, and at the base, close to the bottle, a gutter was formed. As the hollow of the gutter was what may be described as being dry, the presumption is that under certain conditions ice will evaporate without first going through the visible change of melting.

Not only are water pipes burst by freezing, but pump barrels, valves, and cocks are injured by the same action. The writer has seen several of the so-called "diaphragm," both stop and bib, valves with the screws that held on the domical tops broken off. Many ordinary plug cocks are found after a sharp frost to be injured past repair. Fig. 668 is a cross section of a cock showing what occurs. The water pent up inside the key, when shut off, on freezing expands with sufficient force to push out the sides of the barrel at C C, and to break the key across as shown by the double line at D. If we take the breaking stress of gun metal, as used for cocks, as being 36,000 lbs. on the square inch; the thickness of metal at the point of fracture as ⅛ in.; and the length of the fracture as 1 in. for each half of the key, we can approximately find the amount of force exerted by the swelling of the ice. In this case 1 in. × 2 × ⅛ in. = ¼ in. and 36,000 ÷ ¼ = 9,000 lbs., or a little over 4 tons, and this is exerted by less than 1-32nd part of a pint of water inside the key on being converted into ice. The actual force is considerably above 4 tons, but some of it is spent in pushing

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out the sides C C, in the figure. It is highly probable that if the thickness of the metal were three or four times that given above it would have broken by the strain, and this leads to the conclusion that a strain of 12 to 16 tons on the inch is sometimes exerted.

This amount of force points to the almost impossibility of getting lead pipes of such a

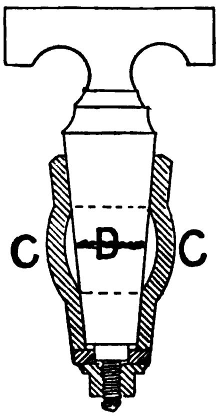

FIG. 668.

substance as to offer resistance to bursting, and to the importance of (*a*) fixing them beyond the influence of frost (*b*) encasing them and (*c*) having them emptied during severely cold seasons.

It has been suggested that if lead pipes had the sides fluted or corrugated, they would not burst, but be forced into a cylindrical form by the expanded water on being frozen.

Mention was made on this matter in an earlier lecture (see p. 206, vol. 1.), but we may here add a list of materials which are bad conductors of heat or cold and are good for packing round water pipes when of necessity they must be fixed where they are liable to become frozen. These are:—Cotton wool, wool, ashes, sand, cokedust, sawdust, charcoal powder, cork chips, plaster of Paris, hair felt, asbestos *, fossil meal *, Leroy's composition *, silicate cotton or slag wool *, and a great many others. In the list those marked with an asterisk are best, and some of them can be had in such forms that they can be applied or fixed without any wooden enclosure. Hair felt is not advised for use as the writer has several times had to remove it, when used for packing pipes, especially when in warm positions or near those for hot water, on account of moth propogating in it. Fossil meal, Leroy's composition, and such like materials are also useful for covering cold water pipes when there is a liability of their being objectionable owing to suspended moisture in the air condensing on them and wetting the surroundings. Or for covering boilers, cylinders, and hot water pipes for preventing the loss of heat by radiation.

HYDRAULICS.

Spouting Jets of Water.

WE have already dealt with "water pressure" when that liquid is confined in any vessel or enclosure, and we may now deal with it under the above heading. For water to spout out of an opening there must be a source for it to come from, and the latter must be higher than the orifice from which it escapes. When the well was being sunk in the forecourt of the National Gallery the workmen broke through an impervious material they came across, and the water spouted up so quickly that they had to clamber out as quickly as possible, not having time to get out their tools. Rumour gives it that the latter are at the bottom of the well to this day.

At a mansion in Buckinghamshire the water spouts out of an artesian well to a considerable height above the ground and fills a tank in the upper part of an outbuilding. Fig. 669 is a sketch section of the house and site on which it stands. In the figure, E is the house and F the outbuilding in which the tank is placed; G is a 4 in. iron pipe, driven into the ground to the water-bearing stratum. The tank is some 16 ft. or 18 ft. above the ground, and the water flows into this without pumping. The stratum, H, is filled with water caught on higher land some miles away, where it crops out at the surface, and is between two layers of impervious material. These prevent the water escaping, thus impounding it and forming an underground reservoir. As the water rises to the height shown by the dotted line, I I, we at once come to the conclusion that the source is at or above that level, and if it were not for the upper layer of impervious matter the water would saturate the whole of the ground or rise above it and form a lake, provided the quantity was sufficient and did not run away on the surface. In the figure, J J is a moat filled with water and surrounding the man-

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sion. There are many cases of water spouting, generally known as "artesian wells," but this one is mentioned as it came under the writer's own notice. In Monmouthshire he had an experience where water spouted up a few inches above the paved floor of a tank built over a spring which was being impounded for supplying a mansion. There is little doubt that many readers have had similar experiences of this kind, and of water escaping out of the ground in the form of springs, as they are generally called. Natural fountains are water under pressure, spouting out of openings in the ground or rock.

If water is confined in a vessel and allowed to escape out of an opening, the velocity of escape can be computed. To do this we must have certain fixed rules to aid us when making calculations. We are taught that all

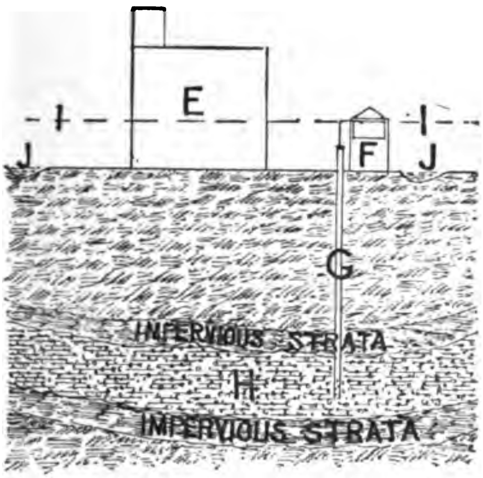

FIG. 669.

bodies fall with equal velocity in a vaccum, or space empty or devoid of all matter or body. The rule for falling bodies is $V=8{\cdot}025 \times \sqrt{H}$ in which V is the theoretical velocity in feet per second and H is the head or height from which they fall. As an example, a body falls 20 ft., what is its velocity?

$H=20$ and $\sqrt{20}=4{\cdot}472$ and $4{\cdot}472 \times 8{\cdot}205=35{\cdot}88$ or 36 ft. nearly per second as the velocity it has acquired at the moment it has fallen 20 ft.

The same rule applies to the discharge of water through an orifice or opening in a cistern or tank. Let Fig. 670 represent such a vessel kept full of water and having an opening in the side at K. If the distance or height of the surface of the water is 4 ft. above the opening, measuring from the centre of the latter, we then have $\sqrt{4} \times 8{\cdot}025=16{\cdot}05$ ft. as being the thoeretical velocity of discharge per second of time. In practice it is usual to leave out the decimals and use the whole numbers only. In the above case it would then be $\sqrt{4} \times 8=16$.

If we know the size of the opening we can then calculate the number of gallons that would flow out in any given time. Before taking an example it will be an advantage to deal in an elementary form with the capacities of pipes.

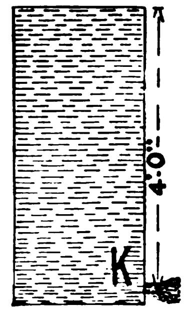

FIG. 670.

If we have a square pipe measuring 1 ft. each way, and a round pipe measuring 1 ft. in diameter, the size of the former would be represented by 1, and that of the latter as ·7854, or considerably smaller, the length of pipe in each case being the same. If we were to divide 1 ft. of the square pipe, on the lines shown by Fig. 646, we should get 144, or the number of 1 in. square pipes which would hold the same quantity of water as a similar one whose sides measured 1 ft. each way. It is not possible to cut up a circular pipe in the same manner, but by calculation we find that 144 circular pipes 1 in. in diameter have the same holding capacity as one pipe which measures 1 ft. across. This is based on the rule, *circles are to each other as the squares of their diameters.* To find the contents of a circular pipe we square the diameter and × by ·7854. As an example, what are the contents of 1 ft. of pipe 6 in. in diameter? Then 6 in. = ·5 of a foot and $\cdot5^2 \times \cdot7854=\cdot19635$ of a foot. To convert this into gallons we multiply by the number of gallons in 1 ft. or 6·25.

Then $\cdot19635 \times 6{\cdot}25=1{\cdot}227$ gallons contained in a 6 in. pipe which is 1 ft. long. Those who have worked out these problems will find that a good number of figures are required and that it would be an advantage to have a short rule that could be easily remembered. As ·7854 and 6·25 are constant multipliers for these problems it will be found convenient to multiply them together and use the product as a constant. That being so we have $\cdot7854 \times 6{\cdot}25=4{\cdot}9$ gallons as a multiplier. This latter can be retained in the memory, and used instead of the others. Not only are fewer figures required and time saved, but there is less liability to error in calculations.

To show how to use this rule we will work out an example. How much water is there in a well which is 5 ft. in diameter?

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Then $5^2 \times 4.9 = 122.5$ gallons for each foot in depth, so that if the water was 10 ft. deep we should have $122.5 \times 10 = 1225$ gallons in the well.

This rule is applicable only when the dimensions are given in feet. When they are in inches the multiplier is ·034, which is found by dividing 4·9 by 144 inches.

We can now go back to Fig. 670 and assume that the opening at K is circular and has a diameter of 2 in. The velocity having already been found to be 16 ft. per second the solution of the problem is as follows :—$16 \times 2^2 \times .034 = 2.176$ gallons escaping per second. If this were multiplied by 60 we should get 130·56

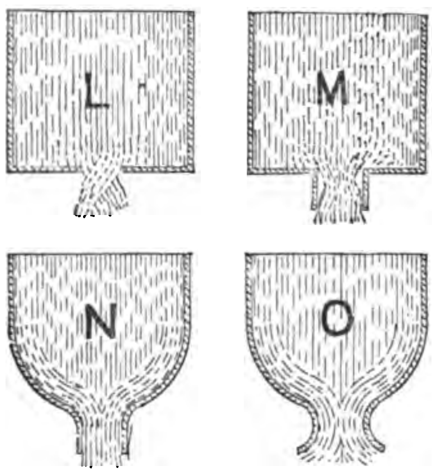

FIG. 671.

gallons discharged in one minute. In this case, too, the rule can be simplified. In the rule for falling bodies the constant figure 8 was given. If this was multiplied into ·034 we should get ·272 for seconds and $\times 60 = 16.3$ for minutes. From this we get the formula $G = \sqrt{H} \times d^2 \times 16.3$.

Where H = the head of water in feet.
„ d = the diameter of the orifice in inches.
„ G = gallons discharge per minute.

To rework the above example with this rule we have $G = 2 \times 2^2 \times 16.3 = 130.4$ gallons discharged per minute.

The above rule gives the maximum or theoretical velocity, and does not hold good under all conditions. The shape and form of orifice frequently having a retarding influence on the speed and quantity of water escaping.

When water is running out of a hole in a tank made of thin plate a great reduction takes place in the area of the section of the issuing stream. This arises from the friction against the sides of the opening, and also amongst the particles of water themselves, and is generally spoken of as the *vena contracta* or contracted vein. Anyone who has been observant may have noticed that a stream of water issuing out of a round hole has not been cylindrical or in a solid jet, but has appeared ragged—if I can be understood by that term—as shown at L, Fig. 671, and not of the full size of the opening. The contraction being at some little distance from the latter and its diameter ·784 as compared with 1 for the orifice. From this we learn that instead of taking the size of the orifice as a basis for calculation we must deal with that of the issuing stream at its greatest contraction. It has been stated above that circles are to each other as the squares of their diameters, and in this case we find that the square of the diameter of the opening compared with that of the contraction is as 1^2 is to $.784^2$ or as 1 is to ·615. In our last rule we had for theoretical velocity a constant multiplier of 16·3, and if we then $16.3 \times .615 = 10$, and our formula for calculating the discharge through a round hole in a thin plate becomes $G = \sqrt{H} \times d^2 \times 10$.

If we again work the problem illustrated by Fig. 670 with this last rule we have $G = 2 \times 2^2 \times 10 = 80$ gallons, or this quantity instead of 130·4 as found by the former rule.

If the side of the tank was very thick, or had a short tube attached, as shown at M, Fig. 671, the area of the contracted vein would not be reduced quite so much, with the result that more water would pass through in a given time than without such tube. If the latter is equal in length to twice the diameter the contraction is ·9 as compared with ·784 for the thin plate. The formulæ for discharge through short tubes is based on this, and found as follows :—

As the diameter of the tube is to that of the water passing through so is 1^2 to $.9^2$ or 1 to ·81 or say ·8. Then 16·3 (see previous rule) $\times .8 = 13.04$ or say 13. The rule then becomes :

$$G = \sqrt{H} \times d^2 \times 13.$$

If we take as an example our previous problems, with regard to head and size of orifice, but with the addition of a short tube twice the length of the diameter, we find that $G = 2 \times 2^2 \times 13 = 104$ gals. discharged in one minute as against 80 gals. for a thin plate and 130·4 gals. the original theoretical quantity.

If the shape of the tube was as shown at N and O, Fig. 671, a larger quantity than 104 gals. would pass through in the same space of time, and would more nearly approach the theoretical. It is not always convenient to have these forms, but plumbers in their work can cone the inlet ends of their lead pipes by opening them with a tanpin, or attach small conical pieces where brass connections are used. In all cases the inlet ends should have the sharp inside arrises taken off, and thus lessen the amount of friction of the passing water. When a cistern is very shallow, or nearly empty, a vortex or whirling motion of the water takes place over the pipe when any is being drawn. On watching this action through

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the sides of a glass vessel or cistern it will be noticed that, the surface of the water being depressed, a core or internal column of air is being carried with the stream. This reduces the quantity discharged and can be partially overcome by fixing a domical cap over the end of the pipe. But it is doubtful if the remedy can be claimed as a success, as the friction in passing under the cap and the change of direction to get into the pipe seriously retards the velocity. A peculiar phenomena of the vortex referred to is the motion being always in the same direction and following that in which the sun moves.

The foregoing remarks apply to what is termed "loss of head," due to "velocity of entry," and also to the *vena contracta* or contracted vein. That is, a portion of the value of the head, or height, the water is falling from is lost, and the velocity of entry into the pipe is retarded to a considerable extent by the influences referred to, so that a lesser quantity passes through than would be the case but for the causes of retardation.

When the pipes have a length much exceeding twice the diameter, what we have above spoken of as short tubes, we have then to take another retarding influence into consideration. When two bodies in contact are moving in opposite directions, or one is fixed and the other in motion, they rub against each other, and a portion of the motive force is either lost or absorbed by the bodies. The loss being power expended to no useful purpose, and the absorption where the results of the applied force is retained

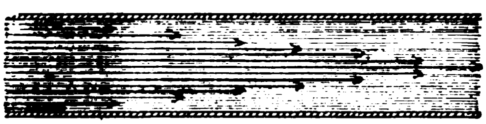

FIG. 672.

in the bodies. A man uses force to throw a cricket ball, but the ball does not travel a distance equal to the energy expended as a great deal is absorbed by the air it passes through, or the turf on which it rolls. But for this the ball would go a much greater distance and travel at a higher rate of speed. This loss is known as "friction," and applies to liquids and gases as well as to solids.

When water is passing through any kind of channels, it rubs against the sides and the velocity is retarded by friction. If the channels have smooth surfaces the speed is not checked so much as when they are rough. A leaden pipe with a smooth inside surface will pass more water through in a given time than one of the same size made of iron which is very rusty. A body of water passing through any channel has not all its particles moving at the same rate of speed. Assuming that those against the sides travel at a certain rate, as shown by the short arrows in Fig. 672, then an inner portion, having only the friction of water to overcome, will flow much faster as shown by the next arrow. And so on to the centre portion which travels at the highest speed of all as it has less resistance to overcome. Or, to put it in another form, assuming that water passing through a pipe is composed of a series of skins fitting inside each other, those on the outside travel at a lesser speed than those near or in the centre.

On the same principle, bodies moving through air or water carry a skin of the surroundings with them. Several times when travelling in express trains, the writer has tried to gauge the thickness of the skin of air carried along with the vehicle, or carriage, by protruding the tips of his fingers through the open window but, although he failed to accurately judge the thickness, he found that unless they were pushed out some little distance he could not feel any air resistance. Some years ago, a friend of the writer's mentioned a most interesting lecture that had been given on holes, in ships and boats, made with cannon balls. From experiments that had been made the conclusion was come to, that a boat with a hole in its side and travelling at a certain speed would keep afloat, as little or no water passed through, but if the speed was slackened, or reduced, the water at once began to rush in. The boat travelling at a high speed carried an outer skin of water with it which covered the hole, but at a lesser speed this skin, or series of skins, was reduced in thickness and the pressure of water at once caused some to enter.

Friction has a large influence on the quantity of water passing through pipes, and the longer they are the greater the amount of resistance. But for this the speed would increase instead of diminishing, which it is found to do in practice. In hydraulics, this has to be taken into consideration and an allowance made for what is known as "loss of head by friction" in all pipe questions.

The friction of water in pipes increases as the square of the velocity.

As an example, if the water is travelling at the rate of two feet per second and the friction was represented by 1, then if it was made to run at a speed of four feet per second the increase would be as 1^2 is to 2^2 or four times the amount. From this we learn that if a pipe of a certain size will discharge a given quantity of water in a fixed time and it is found necessary to double the quantity in the same time, the friction will be increased four-fold and a great deal of power will be wasted or expended to no useful purpose. To obviate this the size of the pipe should be increased for the additional supply.

The friction in small pipes is proportionately much greater than in those of a larger size.

By calculation we find that 16 1 in. pipes are equal in capacity to one 4 in. But 16 1 in. pipes supplied from the same source, will not deliver so much water in a given time as one 4 in. To explain this we can find the internal surfaces of the pipes and compare them.

One foot of 4 in. has $4 \times 3{\cdot}1416 \times 12 = 150{\cdot}79$

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square inches; and 16 1 in. have $1 \times 3.1416 \times 12 \times 16 = 603.18$ square inches.

Then $\frac{603.18}{150.79} = 4$ times the frictional surfaces of the 1 in. pipes are over the 4 in, thus showing why the given number of small pipes will not pass so much water as the larger one.

The number of gallons represented by the loss of head by friction may be calculated by the following rule:—

$$G = \left(\frac{(3d)^5 \times H}{L}\right)^{\frac{1}{2}}*$$

In which G = gallons per minute.
d = diameter of pipe in inches.
H = head of water in feet.
L = length of pipe in yards.

Assuming that a head of water is 20 ft., the diameter of the pipe 2 in., and the length 500 yards, we then have

$$\left(\frac{(2 \text{ in.} \times 3)^5 \times 20}{500}\right)^{\frac{1}{2}}$$

And $2 \times 3 = 6$ and 6 raised to the fifth power $= 7776 \times 20 = 155520 \div 500 = 311$. Then $\sqrt{311} = 17.63$ gallons.

If the length of pipe had not been taken into consideration and there had been no loss by friction the discharge would have been, as one of the previous rules:—

$$G = \sqrt{20} \times 2^2 \times 13 = 232.44 \text{ gallons.}$$

When bends are made to a radius of not less than five times the diameter of the pipe the amount of friction is little in excess of that through the same length of straight pipe. For this reason all bends should be made what we usually term "easy," and sharp elbows should always be avoided both in cold and hot water pipes. Reference to this was made when writing on soil and ventilation pipes (see the text accompanying Figs. 284 and 285). For an ordinary working rule we may take it that the loss of head by change of direction and friction in a well-made 90 degs. bend in a lead pipe is about equal to that in one whose length is equal to ten to twenty times its diameter, according to the radius to which it is made. Lead water pipes which are crippled in the bends, have bruises in them, are distorted out of shape, or have sharp edges projecting inside at the joints, will not deliver nearly so much water as those which are true in section and are perfectly smooth inside throughout their length. Even lead pipes that have become larger inside by the corrosive action of the passing water, will not deliver such a large quantity owing to the friction on the roughened surfaces and eddies formed by the small hollows, as one that is smooth and free from such obstructions.

It is very interesting to watch water escaping from an orifice in a cistern bottom and also out of a short tube. In the first case the water sometimes appears to have a slightly circular motion, similar to the vortex that has been mentioned, and the column is broken up by the resistance of the air which meets it when falling. In the latter case the water passes out in a more solid and compact body. But as the velocity increases as it falls the column becomes more and more attenuated with swellings at intervals, and finally breaks up into drops, as I have endeavoured to illustrate by Fig. 673. This tends to prove that the friction is less when passing through air than through the short pipe or tube.

Although we have dealt with our subject in a very elementary manner, we have learnt a few rules that are of use to us in our everyday work. Those who wish to extend their knowledge should study Box's Practical Hydraulics,

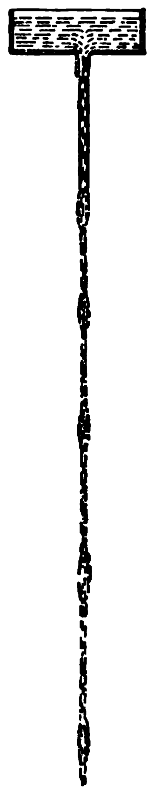

FIG. 673.

Neville's Formulæ, and other engineers' books on the subject.

To show how to apply what we have dealt with we can work out a few problems which occur in practice. Assuming we have an ordinary flushing rim W.C. and a 3 gal. syphon action flushing cistern, the centre of the latter being fixed 4 ft. above the basin. In practice it is found that most of the common washout and washdown W.C. basins in use require the flush to extend from four to five seconds. If the time of the flush is too short the basin is flooded,

* Box.

owing to the resistance of the standing water in the trap, resulting in paper and feculent matter floating on the surface and afterwards being left in view in the trap. If the flush is limited in quantity, and is too long in entering, the basin is not cleansed or the trap cleared. In practice it has been found that an inch and a quarter pipe is the best size to use for most kinds of W.C.'s.

With four feet head the velocity, as found by the rule before given, would be 16 ft. per second. The capacity of one foot of $1\frac{1}{4}$ in. pipe equals ·053 of a gallon as found by the rule: Diameter squared × ·034 equals gallons per foot run of pipe. Three gallons ÷ ·053 = 56·6 as length of feet of pipe holding the given quantity. If 16ft. of this pipe is emptied in one second, then 56·6 ÷ 16 = 3·53 seconds as the time occupied for the flush to pass through. If the latter was limited to two gallons the time would then have been 2·36 seconds with the head and size of pipe as given. But we never find a two-gallon flush with four feet head to empty as quickly as this, and our previous rules partly explain why. For instance, if the formula

$$G = \sqrt{H} \times d^2 \times 13$$

was used the result would have worked out 40·625 gals. per minute, or ·677 gals. per second, or 2·7 gals. in four seconds. But as this does not actually take place in practice we have next to consider why this is so. In the first place, we have only allowed for the contracted vein and velocity of entry in an ordinary pipe. If the flushing cistern is syphonic acting, then there is the friction of the water passing through the pipe or syphon to which must be added that of the down pipe to the W.C. Very few of these pipes have less than four bends, and they are frequently made so as to have contracted ways through them. To flush a basin properly, the pipe must enter the arm in a straight line, otherwise more water will pass round one side than the other, and thus create a whirling motion which almost invariably fails to clear the trap of deposit. The water escaping out of the pipe strikes against a piece of earthenware inside the rim, placed there for the purpose of deflecting it round the sides. As this piece is at right angles to the issuing stream it retards the velocity, and we have to consider this in our calculations.

Another cause of retardation is the connection of the down pipe to the flushing cistern. Many makers measure the brass unions on the outside and will describe them as $1\frac{1}{4}$ in. when the waterways through are only 1 in. Very few, indeed, have clear, or full ways of the nominal sizes.

It is almost impossible to give a rule which shall be generally applicable, but for all round practical purposes we may assume that the actual is only three-fourths of the theoretical discharge of pipes for flushing W.C.'s under the conditions that we have assumed. Then with 4 ft. head and a three-gallon flush through an $1\frac{1}{4}$ in. pipe we find that 4·7 seconds, and a two-gallon 3·14 seconds, are occupied respectively. To reduce the time, which is not always advisable with some kinds of W.C. basins, the cistern can be raised or the size of the pipe increased, but this latter is of very little advantage unless the connection is also enlarged. In all cases sharp, or an unnecessary number of, bends should be avoided. It is also important that the down-pipe should be fixed so as to drain empty and no water be allowed to lodge in any horizontal part.

Service Pipes for Baths.

If we take a case of a service to a bath, the pipe being 1 in. and the cistern fixed 16 ft. above. We then have $\sqrt{16} \times d^2 \times 13 = 52$ gallons as the theoretical discharge in one minute. In this case, too, the pipe may take a winding course and the way through the supply valve, and stop cock if one, slightly contracted or of such a description that the water has to change its direction one, two or three times, as illustrated by Fig. 427 in Vol. I. For rough approximation we may take the actual as being ·75 of the theoretical discharge. Then 52 × ·75 = 39 gallons as running into the bath in one minute.

Waste Pipes.

We may apply the same rule to emptying the same fitting. Or, for the sake of variety, we may transpose the rule that we have been using, so as to find the diameter of the pipe instead of the quantity discharged in a given time. The rule arranged as a formula is:--

$$d = \left(\frac{G}{\sqrt{H} \times 13}\right)^{\frac{1}{2}}$$

G = Gallons discharged per minute.
H = Head of water in feet.
d = Diameter of pipe in inches.

If a bath holds 40 gallons and it is required to empty it in one minute, find the size of the waste pipe to do so. Before working this out we must first take into consideration several details in connection. In the first place the water has to pass out of the bath through small holes in the bottom. These are frequently found to be so small in size, few in number, and in some cases partly choked with fluff and soap curds, as to prevent free escape of the water. If the waste pipe is larger in size than the waterway through the grating it will soon become lined with slimy filth. From this we find that to empty a bath in a given time, not only the waste pipe but the other passages through which the water runs must be of equal area. And this includes the waste valve or cock and the trap. Even when this is so, the constant change of direction and friction, against the sides of the pipe and fittings, has a serious retarding effect, over and above the allowance made for velocity of entry and the vena contracta. The "head" of water is only equal to half the depth of that in the bath. The waste pipe may be continued downwards several feet, but this does not add

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much to the head as in practice it is usual to ventilate the waste and this at once destroys any value that may be attached to the vertical length. If allowance is made for this and we again take 75 per cent. as the maximum of discharge after allowing for friction, &c., we have $40 + 10 = 50$ gallons which should be the basis of the calculations in our assumed problem.

Baths vary very much in shape and a given quantity of water is not of the same depth in all. If we assume that the depth in our problem is 16 in. and $\div 2$ we get a mean of 8 in. or ·66 of a foot. If we add to this the distance the discharging end is below the bath and assume it to be 8 in., or ·66 of a foot also, we get $\cdot66 + \cdot66 = 1\cdot33$ ft. as available head. Our problem then resolves into

$$d = \left(\frac{50}{\sqrt{1\cdot33} \times 13}\right)^{\frac{2}{5}}$$

Then $\sqrt{1\cdot33} = 1\cdot1542 \times 13 = 15$, and $50 \div 15 = 3\cdot33$ and $\sqrt{3\cdot33} = 1\cdot82$ inches as being *d*, or the diameter of the pipe to empty the bath in one minute. The nearest stock size is 2 in and this would be necessary under the conditions we have dealt with.

If the bath is to be emptied in four minutes we find that four times the time is occupied and a pipe ½ the size would be required. That is, a 1 in. pipe will approximately discharge as much water in four minutes as a 2 in will in one minute. This should be accepted as a rough working rule only, and as being near enough for the small problems that plumbers have to deal with.

Water Mains.

For more extensive problems the relative discharging powers of pipes have to be considered. Reference has before been made to the excess of friction in small pipes over those of larger size. Assuming that we have to deal with a water main supplying the houses in a street and it is found that a ½ in. pipe is necessary for each house. If the main is 3 in. in diameter, to find the number of houses that can be supplied from it we have to introduce a new rule, which is based on the discharging powers of long pipes. These vary as the square root of the fifth power of their diameters. That is, with diameters in the ratio 1, 2, 3, 4, the discharge will be in the ratio $1^{2\cdot5}$, $2^{2\cdot5}$, $3^{2\cdot5}$, $4^{2\cdot5}$, and so on. Then with a 3 in. pipe and ½ in. branches we have $3 \text{ in.} \div \cdot5 \text{ in.} = 6$ the ratio of the diameter of the 3 in. to the ½ in. And 6 raised to the fifth power $= 7776$. Then $\sqrt{7776} = 88$.

Thus we find that a 3 in. main will supply 88 houses with a ½ in. branch to each. If each house required a ¾ in. pipe and the main was 4 in. we have $4 \text{ in.} \div \cdot75 \text{ in.} = 5\cdot33$ as the ratio of the 4 in. pipe to the ¾ in. Then $5\cdot33^5 = 4301$ and $\sqrt{4301} = 66$, the number of ¾ in. pipes that a 4 in. main will supply.

General Services.

In these problems the head of water and length of pipe are assumed to be constant. When we come to deal with the service-pipes in a house the given rules will not apply, as the head and length vary very much. To explain this we can assume that a cistern at the top of a house has a pipe leading from it, the latter having branches to fittings in various positions and at different levels, as shown by the diagramatic sketch, Fig. 674. If all the cocks shown at A^1-A^4 were of the same size they would not all discharge the same quantity of water in the same amount of time owing to the difference in head or height of the supply cistern above them. Applying our rule for falling bodies, the cock, A^1 being 16 ft. below the surface of the water in the cistern, we find that $\sqrt{16} \times 8 = 32$ ft. per second as the theoretical velocity of discharge at that position. A^4 being 49 ft. below the cistern, we have $\sqrt{49} \times 8 = 56$ as the theoretical speed at which the water escapes at the lower level. If the service-pipe was of the same size as the cocks, and A^1 and A^4 were opened at the same time nothing would pass out of A^1, but air would be drawn in, as the water below it would be travelling at a

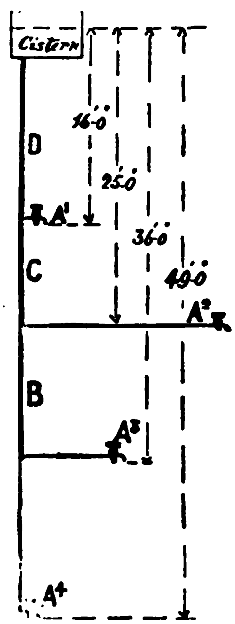

FIG. 674.

higher speed than that above. Not only is this theoretically correct, but it is found to be so in practice. To prevent this the size of the main pipe must be increased. It is not necessary to do this the whole length, but by degrees as we get nearer to the cistern. To work out the sizes to the different floors we will first assume

that the cocks are what is called ¾ in. Such a cock at A^4, fixed on a ¾ in. pipe, with the given head would allow the water to escape with such violence as to knock a tumbler or a pitcher out of a person's hand. To break this force the pipe could be reduced with advantage to ½ in. A_3 could be a ⅝ in. branch pipe, and A^1 and A^2 ¾ in. The cocks in each case being ¾ in. Working out our problems on these lines and assuming that pipes are to each other as the squares of their diameters, we have a ½ in. pipe below the branch to cock A^3. From A^3 to A^2 the main pipe should be equal to a ½ in + ⅝ in. Then ½ in = ·5 in. and ⅝ in. = ·625 in. and $\cdot5^2+\cdot625^2=\cdot64$. Then $\sqrt{\cdot64}=\cdot8$ in. = the diameter the pipe should be at B. From A^2 to A^1 the main pipe should be equal to ·8 + ¾ in. Then $\cdot8^2+\cdot75^2=1\cdot2025$ and $\sqrt{1\cdot2025}=1\cdot09$ in. as the diameter at C. For the upper portion we have $1\cdot09^2+\cdot75^2=1\cdot75$ and $\sqrt{1\cdot75}=1\cdot33$ nearly or say 1½ in. pipe at D.

This latter size may be considered as extravagant, and is actually a trifle too large. But the writer has had to look into so many complaints of water ceasing running at one cock when another has been opened that he always advises those given. We are also governed by stock sizes in our selection. In the above case the pipe at D would be too small if only 1¼ in., and as 1⅜ in. is not made we must take the next, or 1½ in. pipes for use. In the above working out, allowance has been made for the probability of all the cocks being opened at the same time.

Overflow Pipes.

Overflow pipes should always be large enough to take the water away as fast as it can run in, whether from sink, bath, cistern, wash-basin, safe, or other fitting. Inattention to this detail has frequently resulted in serious injury to ceilings, furniture and other matters. Position and shape of inlet to an overflow should always be studied. Years ago it was the common practice to fix to cisterns what was known as "trumpet-mouthed" overflow pipes, these having "ground in" brass connections to the waste pipes, soldered or screwed to the cistern bottoms, as they were made of lead or iron. As many of these pipes have been found connected with drains, soil, and other foul water conduits, and the water in the cisterns rendered unfit for drinking, by the escaping bad air, the practice is now to continue them into the open air, and the connection made near the top edge of the cistern. Some water companies object to overflows, and insist upon what is generally known as warning, or "tell-tale" pipes, the latter being of a small size and continued to positions which can be seen by the company's inspectors or other officers. If the ball-cocks are out of order and the cisterns fill too full, the water runs out of the tell-tales and draws attention to the matter. But if an accident occurs to the cock, or it is so stiff that it will not close at the proper time, the cistern overflows the sides, because of the pipe not being large enough.

Other points in this connection were referred to in an earlier lecture, see the text accompanying Figs. 390 and 391, Vol. I. Our present purpose is to deal with the sizes. If a cistern is supplied from a reservoir and a quantity of water runs in in a given time the overflow should be large enough to take away the same quantity in the same time. We cannot apply any of our previous rules to this problem for the reason that we had the ends of the pipes covered with water. With an overflow it is not so, as illustrated by Fig. 675. Air is carried along on the surface of the water and a depression is formed at E, the pipe not running full bore. More water would pass through if the end was bent down as shown by dotted lines at F, but for plumbers' practical purposes we had better provide for any maximum of discharge through a short straight tube, as shown in the figure.

To work out a problem we may assume that a ball valve has broken down or become useless and the water is running in at the rate of 50

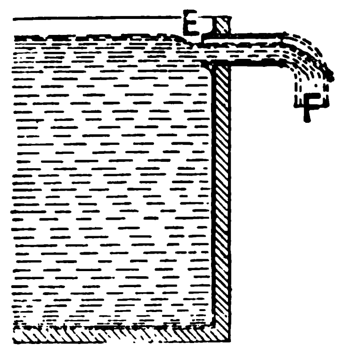

FIG. 675.

gals. per minute. The overflow should be large enough to discharge not less than the same quantity in the given time. To find the discharge for a common overflow pipe Mr. Box gives an approximate rule—

$$G=d^{2\cdot5}\times3\cdot2$$

In which G = gallons discharged per minute, and d = diameter in inches.

So that if the diameter of the overflow is 2 in.

$$G=2^{2\cdot5}\times3\cdot2.$$

Then 2 raised to the fifth power = 32.

And $\sqrt{32}=5\cdot657$ nearly.

And $5\cdot657\times3\cdot2=18\cdot1$ gallons discharged through the overflow in one minute.

In our cistern problem we have 50 gallons to get rid of in that time, and from this we find that a 2 in. pipe is not nearly large enough.

To find the actual size we must transpose the rule as follows :—

$$d=\sqrt[2\cdot5]{\left(\frac{G}{3\cdot2}\right)}$$

The quantity being 50 gals. we have—

$$d=\sqrt[2.5]{\left(\frac{50}{3.2}\right)}$$

Then $50 \div 3.2 = 15.625$.
And $15.625^2 = 244.14$.
And $\sqrt[5]{244.14} = 3$.
From this we find that a short straight overflow pipe, with open ends, the inlet not being immersed beyond its depth, must be not less than 3 in. in diameter to discharge at the rate of 50 gals. per minute.

As students may have some difficulty in finding the square roots of fifth powers, or the fifth roots of squares, a short table is here given:—

Relative dimensions or diameters of pipes.	Relative discharging powers.
·25	·031
·5	·177
·75	·485
1·	1·
1·25	1·747
1·5	2·756
1·75	4·051
2·	5·657
2·25	7·594
2·5	9·882
2·75	12·541
3·	15·582
3·5	22·918
4·0	32·

To show the application of this table:—
What size overflow pipe is necessary to discharge 70 gals. per minute?

$$70 \div 3.2 = 21.9.$$

Looking for the nearest number in the second column we find 22·918. Opposite this in the first column we find 3·5, the diameter sought.

Or supposing we wish to find the quantity of water an overflow pipe of a given size will discharge. We look in the first column for that pipe, and opposite, in the second column, the discharging power, and multiply that by 3·2.

Example a 2½ in. pipe.

This being 2·5 in the first column, opposite we find 9·882, and this multiplied by $3.2 = 31.62$ gallons, the discharge sought.

As a further example: Supposing it is found that the water supplied to a house has been running to waste through a cistern overflow at the rate of 26,000 gals. in twenty-four hours.

On looking into the cistern it is discovered that the pipe is only just large enough to take the water away. What is the size of the pipe?
Then $26000 \div 24 = 1083$ gals. per hour.
And $1083 \div 60 = 18$ gals. per minute.
And $18 \div 3.2 = 5.625$.
On looking in the second column we find the nearest number is 5·657, and opposite this, 2, or the diameter in inches of the overflow-pipe.

The same reasoning may be applied to bath, sink, or wash-basin overflows, but in these latter cases it is usual to have gratings over the inlets, and the size of the aggregate of openings should be taken as the basis for calculations instead of the size of the pipes. The former are usually found to be much smaller (although they should not be) than the latter and will pass a considerably lesser quantity of water.

As already stated, the above rule is only approximately correct, but is sufficiently so for the elementary problems that plumbers have to deal with.

COVERING STAIRS AND LANDINGS WITH LEAD.

HOW many business people are there who, when giving instructions to their juniors or subordinates, conclude with the exhortation, "And hurry up!" And how many people, when endeavouring to obey the order so laconically given, come to grief by slipping or falling on the road over which their errand leads them? Elderly people, too, even when not "hurrying up," frequently have serious falls when going about either on business or for pleasure. Hospital surgeons are constantly having such accidents to deal with.

Many cases occur in private houses where the rooms, passages, and staircases have the floors covered with carpet, linoleum, or other non-slipping material. Even a member of the Royal family has been a victim, and readers will doubtless remember the serious fall the then Prince of Wales had in 1899 through slipping on a staircase.

But in offices, warehouses, railway stations, public buildings, and similar places, such floor coverings are not much used, and neither would they resist the wear and tear of the many feet of passers, some of whom are carrying burdens, and who generally follow each other on almost the same tracks, in many cases with hurried, shuffling steps.

All the accidents are not the results of actual slipping, as many occur from tripping by catching a foot on a projection, or other impediment, such as an unevenly worn floor or stair tread. A person falling on a floor is, generally speaking, not so seriously injured as the one who falls on a staircase and slides and rolls to the bottom. Hence the importance of covering the line of

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traffic in passages and on staircases, especially the latter, with some material which will protect the flooring from being unevenly worn, and on which people can stand or walk without the risk of slipping.

There are many kinds of patented treads for staircases which answer admirably, but some of these are so expensive that they can only be used where the cost can be afforded. Some of them have flush surfaces, but others have sinkings in which dirt can accumulate. For moderate or light traffic good linoleum may last a considerable time and can easily be renewed, but the best material of this kind is not so lasting as sheet lead, which is non-slippery, can be easily repaired or renewed, and the value of the old material is a good set-off against the cost of new.

But even lead coverings have disadvantages unless they are properly fixed. This metal is so soft, and the molecules have such a low standard of cohesion that they will flow by the constant or intermittent application of force in one direction, that is, it will expand or stretch.

If the marks made on the line of traffic on a staircase are examined, it will be seen that when people are going upwards they usually walk one step at a time and tread about 1 ft. 9 in. from the balusters, so that they are able to aid themselves by means of the handrail. But when coming down they do so a higher speed, frequently two or more steps at a time, and tread nearer to the balusters. When turning on a half-landing they do so on the ball of the foot, and wear holes in the covering material by the habit of nearly always treading on the same places. It has been noticed that, such is the force of habit, one person frequently using a staircase will nearly always tread on the same spots and do more injury than would a number of strangers who do not tread in each other's footsteps. Or, to put it in another form, one person using the stairs one hundred times in a day will wear more holes in the treads than one hundred people who use them only once each in the same time.

Fig. 676 is a section of two treads, and at A is shown the flow of the lead caused by those

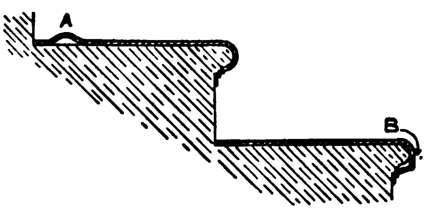

FIG. 676.

going up, and at B by those coming downstairs. Fig. 677 is a plan of a half-landing, showing the parts most worn on narrow staircases over which much traffic passes. In the sketch the lead is assumed to be trimmed a few inches clear of wall of landing and staircase strings, as shown by the shaded parts.

There is some little difference of opinion as to whether the lead for covering stairs should be pure and soft or hardened by an alloy. The soft is undoubtedly the best for preventing slipping, but the hard will wear longer, as it will not flow so much at the sides nor bag over the nosings to the same extent as that which is softer.

Between the two a medium may be taken, and the ordinary lead of commerce accepted as being suitable.

On this subject it may be stated that there is a patented sheet lead on the market which is

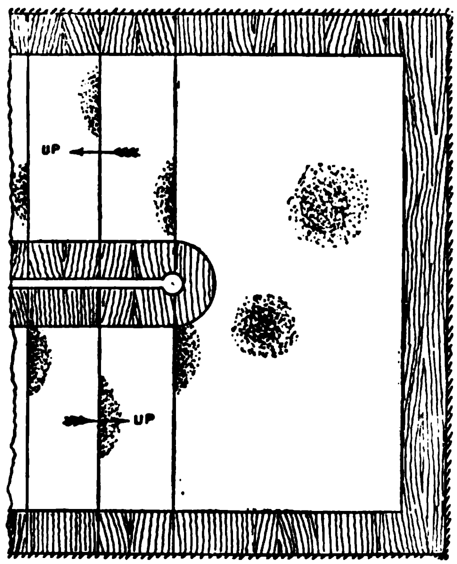

FIG. 677.

manufactured especially for covering floors and staircases, and consists of soft sheet lead in which woven steel netting is milled; the object being to have a non-slipping material which will last for some time, and which will not flow nor stretch, nor bag over the nosings.

The substance of ordinary lead should be equal to what is known as 7 lbs. or 8 lbs. to the square foot, and which is about ⅛ in. thick. So-called 4 lbs. and 5 lbs. lead is not suitable for hard wear, and should be used only where the traffic is very light.

Another question is: Should the "risers" as well as the "treads" be covered? There is no wear on the risers, so there is no necessity for covering them; and it may be considered a waste of material to do so. With steep-pitched stairs having narrow treads, the risers are perhaps bruised by the toes of people's boots; but if they were covered with lead the advantage gained would not be worth the cost. And,

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again, they frequently appear disfigured, or dirty, by the knocking of the toes of blackinged boots, but this can be washed off. or they could be painted the same colour as the lead so as not to show the marks. The risers of stone stairs can be cleaned in the same manner as the other portions exposed. In dark or shaded positions the risers and sides of the treads are best when of a light colour, as the steps are then more distinctive, and users, especially those with weak or short eyesight, can walk with more confidence over them.

Very narrow staircases should have the treads covered their whole width, but with wider steps this would be a waste of material; unless the traffic was very heavy on the latter, and two lines were meeting each other, in which case the treads should be covered the whole width.

Covering Stone Stairs.

Dealing with the practical part of the subject, in all cases it should be a standing rule that the lead to be used should be free from tool marks and scratches, and for this reason it should be rendered flat and smooth by the aid of a flapper made out of a remnant of sheet lead, and hard-wood tools, or dressers, used as little as possible.

Assuming the stairs are quite new and the treads are not worn uneven, for the straights exact measurements can be taken of their length and width; a strip of lead fitted to the step is the best for the latter, and the lead cut rather full to the sizes thus obtained. The edges should then be made perfectly straight and true by means of a plumber's plane, or a carpenter's jack-plane with a steel face answers very well. This is far better than laying the lead in a rough manner and dressing and trimming afterwards.

Half-space and quarter-space landings can have the lead cut out and planed true as for the straight steps. For the winders, brown paper patterns can be fitted and then used for marking out the lead. But it is much better to set them out on plan with chalk lines on the workshop floor, lay the pieces of lead to be used on the lines, and thus get the exact size and shape of the treads, to which should be added a margin for turning round the nosing. After cutting out the edges can be planed true, as described for the straight

In most cases the steps vary a little, and for both straights and winders it is an advantage to leave the back edges of the pieces of lead rather full, so that if there are any little variations in the width of the treads, each piece can be planed down, after a trial fit, to the exact size.

Some stone staircases have the treads and risers with a square front edge; others have a round nosing to the step, and others a similar nosing with a small moulding beneath. It is very rarely that the first named is covered, but the last two are frequently done, especially in Government offices and public buildings. When there are many steps to be done, a wooden dummy should be made to the required pattern and used for working the lead to the desired shape. The dummy can be made of deal, but the nosings and mouldings, if any, should be of oak or other hard wood, and the depth from back to front large enough for working winders as well as straights. For a plain round nosing, the lead should be worked round it and about one inch down the riser. With a moulded nosing, the lead should be worked about one inch below that. In some cases it is worked only round the nosing, but this is not a good method as, after a time, the edge will turn outwards and those who may be walking upstairs will perhaps catch their toes against the loose edge and fall forwards. When worked on a dummy there is no necessity for dressing the lead when in its position, and tool marks are thus avoided.

There are various methods of fixing the lead, and each has its advantages and the contrary. One is shown in section by Fig. 678, and consists of dovetailed grooves cut in the tread and riser, into which the back and front edges are chased and then filled up flush with molten lead.

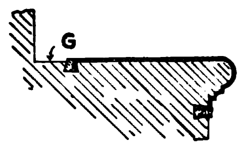

FIG. 678.

This fixing is strong, but it is difficult to repair or renew the lead in a neat manner. Worn patches can be cut out and new pieces inserted and "burned in" with a flam, and cleaned off, but on taking away the whole of a step for renewal the stone is broken on each side of the grooves. There is also a small sinking at G in which dirt can accumulate.

Another method is shown in section by Fig. 679. In this case the grooves are cut and slightly dished on each side. They are then

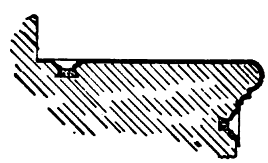

FIG. 679.

filled with molten lead even with the bottom of the dishing. The cover lead has slits cut to fit over the dowel lead and is dressed into the sinking, then soiled, shaved and soldered by a flush wiped seam. Brown paper should be placed between the stone and lead on each side of the seam for preventing the solder being

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chilled when wiping. This method is a very troublesome one for the plumber, as the applied heat causes the lead to expand and the edges to curl up and show through the soldering. When

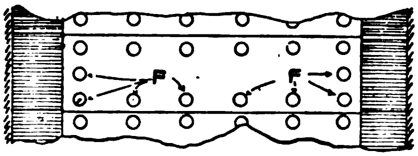

Fig. 680.

necessary to renew the lead the metal can be melted off with a blow-pipe or gas jet, the old lead taken away, the new fixed and the soldering redone.

Fig. 680 is a plan of one step, and Fig. 681 a section, showing the cover lead fixed with lead dots or dowels as often practised. The fixing is fairly good, but the raised dots are objectionable. Neither can they be easily cut out when renewal of the treads is necessary. A better method is to cut and dish the dowel holes in the stones, fill them with lead flush with the bottom of the dishing, lay the cover lead, cut the necessary holes through it and, after preparation, wipe flush soldered dots. In this case, too, the solder can be melted off, the lead exchanged and the dots resoldered as when first done.

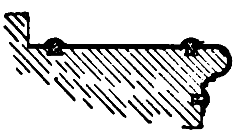

FIG. 681.

When the cost is not a bar, a really good fixing is shown by Fig. 682. In this case holes are cut, and brass dowels, with screws, fixed in them with lead. A brass angle-bar at C, a flat brass plate at D, each the full length of the step, and circular brass plates about $1\frac{1}{2}$ in. in diameter by 1-8th or 3-16th of an inch thick, let in flush as show at E, in the positions F F, Fig. 680, securely holds the lead when fixed by the screws. The end plates help to prevent the lead spreading at the ends, and those near the front edge from bagging over the nosing. The small circular plates at F F, Fig. 680, should be about 12 in. to 15 in. apart, and fixed not too near the nosing or there would be some risk of bursting off pieces of stone when the mason is cutting the dowel holes. The plate at C, Fig. 682, fills the angle and prevents an accumulation of dirt at that place, and also helps to prevent the riser being disfigured by the toe marks of those who kick against it. By simply taking out the screws the brass plates can be removed, the old lead taken away and new substituted with very little trouble. With spandrel steps the dowel at C would have to be a little different to the drawing, or it would show through the soffit beneath.

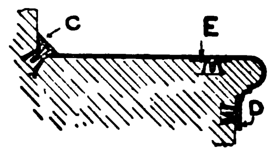

Fig. 682.

When it is desired to cover an old stone staircase the treads of which are much worn, great pains have to be taken to first prepare the stonework. Unless this is done the job looks wretched when completed and the lead will not last any great length of time. The really best method is for the mason to cut out worn parts and insert pieces of stone so that the form and shape is as when first constructed.

In many cases, attempts are made to level the steps by filling up any hollows with plaster of Paris or Portland cement. But this is not at all satisfactory, as, in addition to the difficulty of making the surface even and as when originally made, the filling-up material breaks or cracks and works loose, especially at any thin edges, causing bumps and hollows to show through the lead. When of necessity such methods have to be practised the lead should be worked on a dummy to fit the steps, then placed in position and fixed. If at all possible to avoid doing so, neither a dresser nor a flapper should be used on the lead when in its position, as such working aggravates matters and results in the work looking uneven and unsightly when finished.

COVERING WOOD STAIRS.

Buildings having stone staircases are, speaking generally, usually of a better or higher class character than those with wood. Many, including private or dwelling houses, are constructed for especial purposes, but after a time are converted into offices, warehouses, restaurants, and similar quasi-public uses. Even when newly constructed economy frequently has to be practised and wood stairs are fixed, to be afterwards protected by lead coverings.

Fig. 683 is a plan and Fig. 684 a section of a very common kind. The treads of many of these are made of deal about 1 in. thick, and

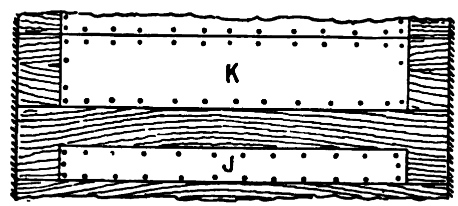

FIG. 683.

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covered on the front part only, as shown at J J. When first done it can be made to look neat, but where there is much traffic the life is very short. This is a very poor job, and a better one is shown at K K. As the wood treads are very thin the nosing forms only a small round of ½-in. radius, and by stepping upon it the lead is dragged downwards, or worn through on the edge. As shown in the drawing, there is a row of nails beneath the nosing and also on the top of it, which gives the appearance of firm fixing. But owing to the thinness and softness of the woodwork these nails have very little grip, and are dragged out so that they follow the flow of the lead. If of a good size the nails split the

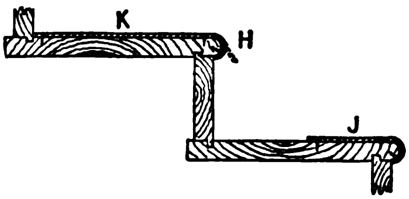

FIG. 684.

nosing off the step, and if they are only ⅝ in. long and driven in an inch or so apart they have the same result. Over and over again, the present writer has found the nosing broken down, and when the foundation has gone there is then no support or fixing for the lead. When repairing such staircases the deal nosing of the treads as well as the lead has frequently to be renewed. After the lead has been renewed two or three times, so many holes have been made that there is no longer any grip for the nails. When the whole depth of the stair-tread is covered the nails can be driven in further apart, and the woodwork is then less injured; but the trouble of the front edge, which is nailed to the under-side of the nosing, still remains. This edge frequently curls outwards, as shown by dotted lines at H, Fig. 684, and results in many accidents to those walking upwards. Sometimes the nailing is done on the front of the nosing instead of the underside, but this method is worse than the other and aggravates the evil referred to.

With good substantial oak or teak staircases, a much better job can be made. The treads being thicker, slightly stronger nails can be used and driven in further apart. The front nosing can also be made more rounded and thus present a larger surface for stepping upon, as can be seen by comparing those shown by Figs. 678, 679, 681 and 682, with that shown by Fig. 684, and which would result in the lead wearing longer. But the nosing should not be too much rounded, or it would form a slope on which people would slip.

With wood as with stone stairs the treads need not be covered their entire length, excepting under the special circumstances which have been referred to. Neither is it advisable to cover the risers, as this adds to the dark appearance of the staircase and renders it less easy to distinguish the steps. And, again, the lead does not look so smart as the woodwork, especially when the latter is French polished.

Fig. 685 is a plan of the lower steps, covered with lead, of a polished oak staircase in a City office, and which was done by the present writer some years ago. The whole of the treads,

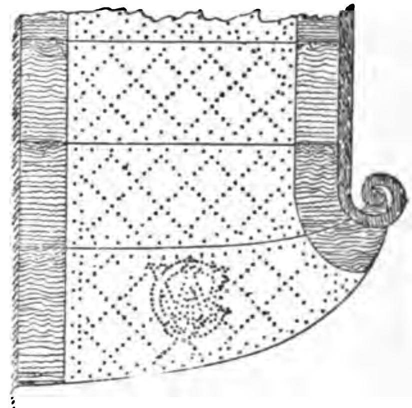

FIG. 685.

excepting the two lowest, were prepared on a dummy and fixed without doing any injury in any way to the exposed polished woodwork. Paper patterns were made and used as stencils for the nailing, which it was desired should look nice.

For ordinary work common cut copper tacks with flat heads are used, but in the above case they were wrought copper with slightly rounded heads. The latter are a little more expensive, but are the best, as, owing to their thicker points they drive better; the rounded heads help to prevent people slipping, and also protect the lead from wear. When nailing lead with small copper tacks or nails, there is a great waste owing to their bending, especially when being driven into hard wood. It is a real economy to have a short, stumpy bradawl for making the holes to a depth of about half their length, so that two or three light blows with a hammer are sufficient to drive them home. With cut nails the points are often so very thin that they bend sideways, and in that position are driven into the face of the lead, out of which they have to be prised, ugly marks being made in the process. Even when such nails drive all right, in the endeavour to get the heads level with the lead, hammer marks are made on the latter and look unsightly, especially when the tool has sharp edges or a hollow, broken face.

As with stone stairs, so with those made of wood; brass bars and plates for fixing the lead

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are much the best and, when kept well polished and bright, look smart and help to show up each individual step so that it is conspicuous to the eyes of those who use the staircase.

During an employment extending between two and three years at a plumber's shop in the City of London, the writer frequently had to repair the lead on the staircases of offices and restaurants, and in order not to interfere with the business of those establishments had to work during the night-time. Sometimes not only was the lead worn right through in places, but also the woodwork to a considerable extent. Many of them had been repaired so many times that the nails would scarcely hold. Time not allowing for renewing the wood treads the repairs had to be done as best he could by the plumber, and he had to level up worn places in the woodwork by pieces of lead shaved down to feather edges. In some cases the hollows were filled up (although the stairs were wood) with plaster of Paris; and other schemes had to be resorted to to make the places safe for use until a vacation time arrived, when everything could be done in a proper manner. With most of these hurried repairs the worn pieces of lead were cut out and used as patterns for the size and shape of the new pieces, which were then fixed with butt edges to the old lead and nailed with black or iron tacks, copper nails being used only where necessary to match the old work. All this had to be done very quickly, and all loose edges well secured so that people in a hurry could not trip or fall. Not only are the proprietors of the above establishments anxious for their clients' or customers' safety, but also so that they shall not be liable to be sued for any damages or injury that may arise from defective stairs.

Lead on landings and in passages does not require much fixing, excepting near the foot of a staircase, but it should have periodical attention by the plumber. The edges flow outwards in places and should be straightened by trimming with a drawing knife. Sometimes, especially when laid on stone, the edges curl upwards and dirt gets beneath; but this dirt can easily be removed and the lead dressed down close to the floor by a few gentle taps with a flapper, which causes it to fit close to any little irregularities.

In many places, such as the kitchens of clubs, hotels and restaurants, when situated at the tops of the buildings and having rooms beneath, the floors should be watertight and impervious to moisture. In new buildings concrete floors can be constructed, but in old buildings with wooden floors lead is about the only covering that can be adopted or used. But this metal is not entirely satisfactory for this purpose, owing to the greasy condition it gets into and the difficulty of the servants keeping their feet when moving about quickly. Sawdust is sometimes sprinkled about for preventing people slipping, but this is not so good as sand, although it may be thought more cleanly when the uses of the place are considered.

Sheet lead coverings to staircases in railway stations and similar places have not been found satisfactory. Probably this has been because a too rigid economy was practised and light metal used. If heavier lead, say 10 lbs. per square foot, which is about 3-16ths of n inch thick, had been fixed the results would have been different

Numbers of patented treads have been introduced during the last few years, especially for resisting wear by heavy foot traffic, and some of these answer very well, especially those having lead insertions on the surface.

POSITIONS FOR SOIL PIPES.

A RECENT law case has again brought up the question as to whether soil pipes should be fixed inside or outside buildings.

As the subject is one of interest, a short *résumé* of what has been done in years gone by, and thus led up to present conditions, may help to a clear understanding of the problem suggested by the above heading or title, and whether existing regulations on the matter are entirely satisfactory.

As an introduction it may be stated that we have no evidence that, until these last few years, there were any rules or regulations, or guiding authorities, or literature, on the subject. That there was some uniformity of action amongst a section of the older plumbers is only reasonable to suppose, as the whole of the old work now in existence could not possibly have been executed under one man's directions, and yet there is a great deal that was constructed on common lines. If there were any authoritative regulations they have either been lost, destroyed as being of no value, or locked up in the archives of the Plumbers' Company, which body originally took the lead in all matters appertaining to the trade.

It was not until a water supply was introduced into London that water-closets were used. Originally the supply was at such a low pressure that the water would not rise to any great height, and for lofty buildings it ran from the street main into basement tanks, from whence it was pumped by hand to the upper cisterns. Under such circumstances water-closets were not fitted so much in the higher parts of houses as they are at the present time. Hence long lengths of vertical soil pipes were not much used. But as the supply of water

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was increased in volume, a greater pressure was obtained, and iron mains were substituted for those made of wood, sanitary conveniences became more general and were fixed at higher levels, thus necessitating longer stacks of soil pipes.

As upstairs water-closets became more used they were almost invariably fixed in, or near, the centres of the houses, and of necessity the soil pipes were situated throughout their length inside the building. These usually discharged into cesspools constructed beneath the basement floors, and really constituted the drains from the upper portions of the houses. To them were connected the rain-water pipes from the roofs, waste pipes from sinks, and also the waste and over-flow pipes from the cisterns which held the water used for all domestic purposes.

The introduction of a high-pressure service led up to what may be termed a new class of work, for which there were no precedents. Everything must have been done experimentally, although plumbers at that time doubtless gave careful thought and consideration to the work in hand. Little by little they gained experience, and the records of the various patents for sanitary appliances give proof that there were people who were constantly studying how to improve the sanitary arrangements of houses Considerable progress must have been made, and we of the present generation can only claim that we are continuing on the lines of those who lived before us.

On going over several old historical buildings, the writer has never yet seen a stack of soil pipes fixed outside excepting in cases where new or modern sanitary works have been carried out. He has seen a pipe 9 in. in diameter made out of cast sheet lead, and having wiped soldered seams, fixed inside a building, and although there was an inside incrustation, or fur, 2 in. in thickness it was in as good condition (excepting the horizontal portions, the upper sides of which were corroded or eaten into holes by the accumulation of sewage gases inside) as when fixed, perhaps, a hundred years ago.

As to literature, the oldest book the writer has seen on plumbing was shown to him about sixteen years ago by a French friend, a master plumber in Paris. But this did not refer to soil pipes in any way, the principal items of interest it contained being those on casting lead into pipes and sheets.

The earliest modern book the writer can trace was based on a series of articles published in the *Building News* and reissued in book form in 1876. These were written by the late Mr. W. Paton Buchan, of Glasgow, who complained of the want of a text-book on plumbing, and so "had to set to work and make his own notes the best way possible under the circumstances." On referring to this book, the only reference to the position of soil pipes is a statement as to "their liability to being frozen up in frosty weather" when fixed outside, and to the quality of the pipe and method of jointing when fixed inside.

In 1877 Mr. S. Stevens Hellyer, who may be called the pioneer of modern sanitary plumbing, issued a book entitled "The Plumber and Sanitary Houses," in which he states, "when the plumbers are skilled . . . . and where honest materials are used . . . . it matters little whether the soil pipe is inside or outside, but where the builder or plumber cannot be depended upon . . . . or where the handworker is not skilled . . . . I would insist upon the soil pipe being fixed outside the external walls of the house." In a course of lectures given by the same gentleman in the rooms of the Society of Arts, he stated, "I would not pull down a house and rebuild it to get the soil pipe outside, but wherever it is at all practicable, and in all new houses, I would insist upon the soil pipes being fixed outside, unless special circumstances called them inside, and this would, no doubt, be the case in some instances"

In a foot-note the same author says, "The durability of a soil pipe fixed externally, and exposed to the rays of the sun, would be nothing like so great as a soil pipe fixed inside a house or where the sun could not reach it."

In 1884, the year of the Health Exhibition, in a handbook written by the late Mr. W. Eassie, C.E., after describing soil pipes, their construction, &c., the author goes on to say: "The golden rule with regard to soil pipes is to fix them outside the house whenever this can by any means be done." And, again, the same author in "Our Homes" says, "Soil pipes . . . should be on all possible occasions taken up outside the house."

In the same year, 1884, the late Mr. Ernest Turner states, in a small treatise written by himself, "The soil pipe should always be carried outside the building."

In Mr. P. J. Davies' "Standard Practical Plumbing," published in 1885, the position of soil pipes is not dealt with in any way.

In a series of articles contributed by the author to the *Sanitary Engineer*, New York, during the years 1883-7, many actual defects in soil pipes, fixed both internally and externally, that had come under his notice, were described, and in his book, "Lectures to Plumbers,"* he makes the following statement, "prominent sanitary plumbers make it a standing rule to fix the soil pipes outside the house whenever possible. I also think that they should be so fixed, and always do so where I can."

In the Model Bye-laws issued by the Local Government Board in 1877 for the guidance of sanitary authorities, Clause 66 states: "He shall cause the soil pipe from every water-closet in such building . . . . to be fixed outside such building."

In the Bye-Laws made by the London

* 1st Series, p. 125.

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County Council under the Public Health (London) Act, 1891, Clause 4 states, "Any person who shall provide a soil pipe in connection with a building . . . . shall cause such soil pipe to be situated outside such building, and any person who shall provide or construct or refit a soil pipe in connection with an existing building shall, whenever practicable, cause such soil pipe to be situated outside such building, and in all cases where such soil pipe shall be situated within any building shall construct such soil pipe in drawn lead, or of heavy cast iron jointed with molten lead and properly caulked."

Hence we find the general concensus of opinion amongst the leaders in sanitary questions during these last 22 years is in favour of the outside position, in some cases qualified by such statements as "where practicable," or "unless special circumstances called them inside."

In analysing the subject the first question to be answered is: What is a soil pipe? In short terms we may describe it as a "filth pipe," or "a continuation of a filth drain." This being so, why is more stress laid upon the position of a soil pipe or vertical drain, which is accessible for examination or repairs, than upon that of an underground horizontal drain which is inaccessible and can neither be seen nor repaired without going to considerable expense and trouble? Those who have constant experience in such matters know quite well that when testing the sanitary conditions of houses quite as many, if not more, defective drains are found than leaking soil pipes, and consequently the former should have the most careful attention paid to them with regard to position.

A second question is: "Why have so many authorities agreed as to the outside position for soil pipes? To find the root of this we must go back to the time when the doctrine began to be preached. At that time many soil pipes were found to be fixed in all manner of unsuitable positions, such as through drinking water cisterns, food larders, bed and living rooms, &c. Many pipes were found to be old and defective, in some cases patched and imperfectly repaired. The water-closets attached to them were so placed that they could not be ventilated, and the odours from them pervaded the adjoining rooms. Under such conditions it was felt that the only satisfactory remedy was to remove the whole of the appliances and fix them near external walls where light and ventilation could be had in the closets, and the soil pipes could be carried outside instead of passing through rooms or other objectionable places.

At the time this began to be practised the evil effects of sun and weather upon the pipes had not been experienced to the extent that we now know to be the case. An observer cannot but be struck with the number of soil pipes exposed to the sun and broken by its action, even after being fixed for only a few years. 'Tis true the defects are out-of-doors, but if the pipes had been inside they most probably would not have arisen.

A third question is in connection with the rules and regulations issued by sanitary authorities. Laws are made for the benefit of the community and the suppression of abuses. The right-minded individual has no fear of the law, but looks upon it as a protection against those whose principles are not grounded on right lines. Laws, too, are guides for the actions of those who are in doubt as to what is the right thing to do under certain circumstances. Many of the public are limited in their means, others are so infatuated by the principles of cheapness that they allow their houses to become insanitary or do everything as economically as they can and have the cheapest work they can obtain. Hence dishonest tradesmen and those who are lacking in experience execute a great deal of sanitary work in a very indifferent manner, and which would be worse still but for certain laws and regulations to which they must conform. The makers of sanitary laws have to study the people who have limited means as well as those who are rich And such laws have to be made to suit all classes. Hence it is that those who are in authority consider it to be their duty to have the strict letter of the law carried out irrespective of circumstances, and this applies also to those dealing with the positions of soil pipes.

But there is a difference between houses occupied by those with limited means and those who are wealthy. In one case, excepting the public inspector, there is no proper supervision; and in the other nothing is done without an architect, engineer, or other competent person to design and superintend the work when being done by an expert firm who employ only the most skilled workmen and use the best materials.

In mansions, hotels, clubs, and similar high-class buildings, with fronts designed with a view to appearances, it is doubtful wisdom to insist upon having the soil pipes outside, and not only architects but their clients object to an unsightly array of pipes showing on the elevations of their houses.

It may be said that the back sides of buildings are the proper positions for sanitary fittings, but with double-fronted premises, or those with only a light and air shaft at the back or in the centre, consideration should be shown and an inside position allowed. And, again, why should it be imperative that an architect or owner must have the main walls of his buildings mutilated and weakened by cutting large holes through them at each floor level for the branch soil pipes to pass through?

In many large buildings sanitary conveniences are fixed on each floor, and a second pipe, to ventilate the traps, is necessary. This pipe, with its branches, in many cases is fixed inside the building, and as it is filled with air from the soil pipe and drains it is equally dangerous

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with the latter. When fixed outside it adds to the already unsightly appearance and weakening of the walls.

When water-closets are fixed in ranges on the various floors horizontal soil pipes are necessary, and when fixed outside they not only look ugly but there is frequently some difficulty in getting them past windows. With many of the lofty buildings in London the difficulty of repairing a broken pipe fixed outside is very great indeed.

With the materials and skilled labour at command good, substantial work can be done, and, surely, under such conditions some latitude and a departure should be allowed in special cases from rules that have been laid down on general lines, but which are chiefly intended for low-class property which is constructed by inferior builders without proper superintendence. In carefully designed dwellings all sanitary fittings are, or should be, in special wings, in which case the soil pipes should be allowed inside when so desired.

By all means, do everything possible for the benefit of people's health, but it is doubtful if the insistence of an outside position under all conditions is an advantage. But when an inside position is selected, the whole of the soil and other pipes in connection should be tested by filling them with water to ensure the discovery of any possible defects if existing. If this were done there would be no risk of danger of ill-health to those who use such places, and after all that is, or should be, the primary consideration.

To conclude, with an experience of later years, it is the writer's opinion that there should not be any fixed regulations to apply to all classes of work, and that in some cases an inside position for soil pipes should be allowed. And if existing laws are found to work unsatisfactorily, they should be altered or so modified as to meet special cases.

It may be added that it is a serious reflection upon the craft of the plumber if good, sound workmanship of this character cannot be executed in a manner satisfactory and suitable for fixing inside a building.

THE END.

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